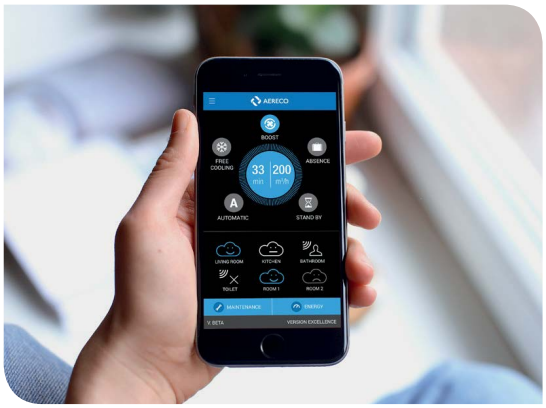

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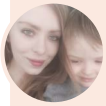

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Fishleys passive house, Worcestershire
Photo by Matthew Ling Photography

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Disclaimer: The opinions expressed in Passive House Plus are those of the authors and do not necessarily reflect the views of the publishers.

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editor's letter

ISSUE 29

For a building to be truly sustainable, context is key. Any notion that a sustainable building can be articulated as a singular, immutable thing is fundamentally wrong-headed. That may seem like a cop out, it may open the door to ill-conceived measures and outright snake oil sales, and it certainly makes the task of winning people over harder. There's a reason why technologies like solar PV are such iconic signifiers of sustainability: they're clear, simple to understand symbols of green-ness. But to quote Oscar Wilde, the truth is rarely pure and never simple.

The centrality of context is how we can arrive at a situation where this magazine ends up featuring a project inspired by passive house principles, designed by some of the UK's leading passive house advocates, built quite deliberately out of concrete and without a pick of insulation, or without any form of mechanical ventilation – let alone a system with heat recovery. The context in which the buildings have been designed – in rural Tanzania – forced the design team to think about a way of delivering the best possible, most sustainable living environment in a manner that would be scalable and practical within a very constrained local supply chain.

Although, due to some of the pragmatic decisions taken by the design team, the Tanzanian project falls outside of the scope of the passive house standard – in that the buildings are expected to be warmer than the Passive House Institute permits, the fact that designs of this nature could come close to passive house is indicative of a point that is seldom recognised: the passive house standard is nowhere near as restrictive as some would you have you believe. The requirements change depending on the context. That's why, even within an island as small as Ireland, the heat load of a certified passive house in sub-tropical West Cork could almost double if relocated to Donegal. It's why quadruple glazing might be required if your site's in the arctic circle, while a house can be certified passive in Mexico City with double glazing and mechanical extract ventilation, and it's why a one-off house may require substantially thicker insulation than an apartment building on the same site, given their potentially vast differences in form, internal gains, etc.

But context in sustainable building isn't just about energy performance, as the special projects profiled in this issue demonstrate. It's about choosing a location that ties the buildings into existing infrastructure and amenities, as is beautifully exemplified by the 12-unit social housing scheme at George's Place, Dún Laoghaire. It's about treading gently on special sites, such as the passive house with timber cladding that references its beautiful woodland setting in Worcestershire. It's about respecting the local vernacular, such as the self-build near Macroom designed to reference the farm-style clustering of buildings so typical of the area. And it's about setting an example that others can realistically hope to follow, such as the cost-sensitive transformation of a cold, leaky ex-council house in Cheshire into a certified passive house – a building so radically transformed that walking through the front door gives its owner a sense of comfort that feels almost magical.

Regards,
The editor

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About
Passive House Plus is an official partner magazine of The Association for Environment Conscious Building, The International Passive House Assocation and The Passivhaus Trust.

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INTERNATIONAL

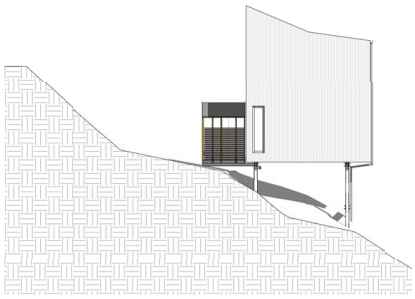
A SELECTION OF PASSIVE & ECO BUILDS FROM AROUND THE WORLD



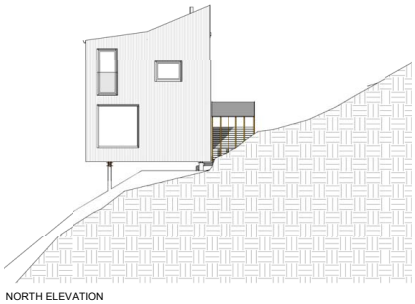


Photos: Simon Devitt

KOWHAI HOUSE, DUNEDIN, SOUTH ISLAND, NEW ZEALAND



SOUTH ELEVATION



NORTH ELEVATION

Designed by architect Rafe Maclean for his own family, the Kowhai House — named after an existing native kowhai tree which now forms a central view from the living room — is perched high on a hillside clad with native trees overlooking the Leith Stream in Dunedin.

With the site's marginal soil conditions and difficult access, the building was designed to be simple in both form and buildability. The house is a gabled rectangle, but with one roof face of the gable roof sloped up from the ridgeline, not down, providing internal space for mezzanine beds.

Because two members of the family are asthmatics, building a certified passive house — with the standard's focus on indoor air quality — made obvious sense. It also helped that Maclean is one of NZ's leading passive house designers.

The house's arrangement had to be efficient but comfortable enough for four people to live together, with each person having their own space. At 116 square metres the house is not expansive, Maclean says, more a comfortable retreat from the city and its challenging climate (Dunedin being often labelled the 'Edinburgh of the south').

With such an airtight structure (0.1 air changes per hour), and low air volume inside the house, the interior is apparently quite sensitive to overheating. However Maclean says this has been successfully mitigated by adjusting ventilation rates when needed, and by night time flushing through windows for short periods when required.

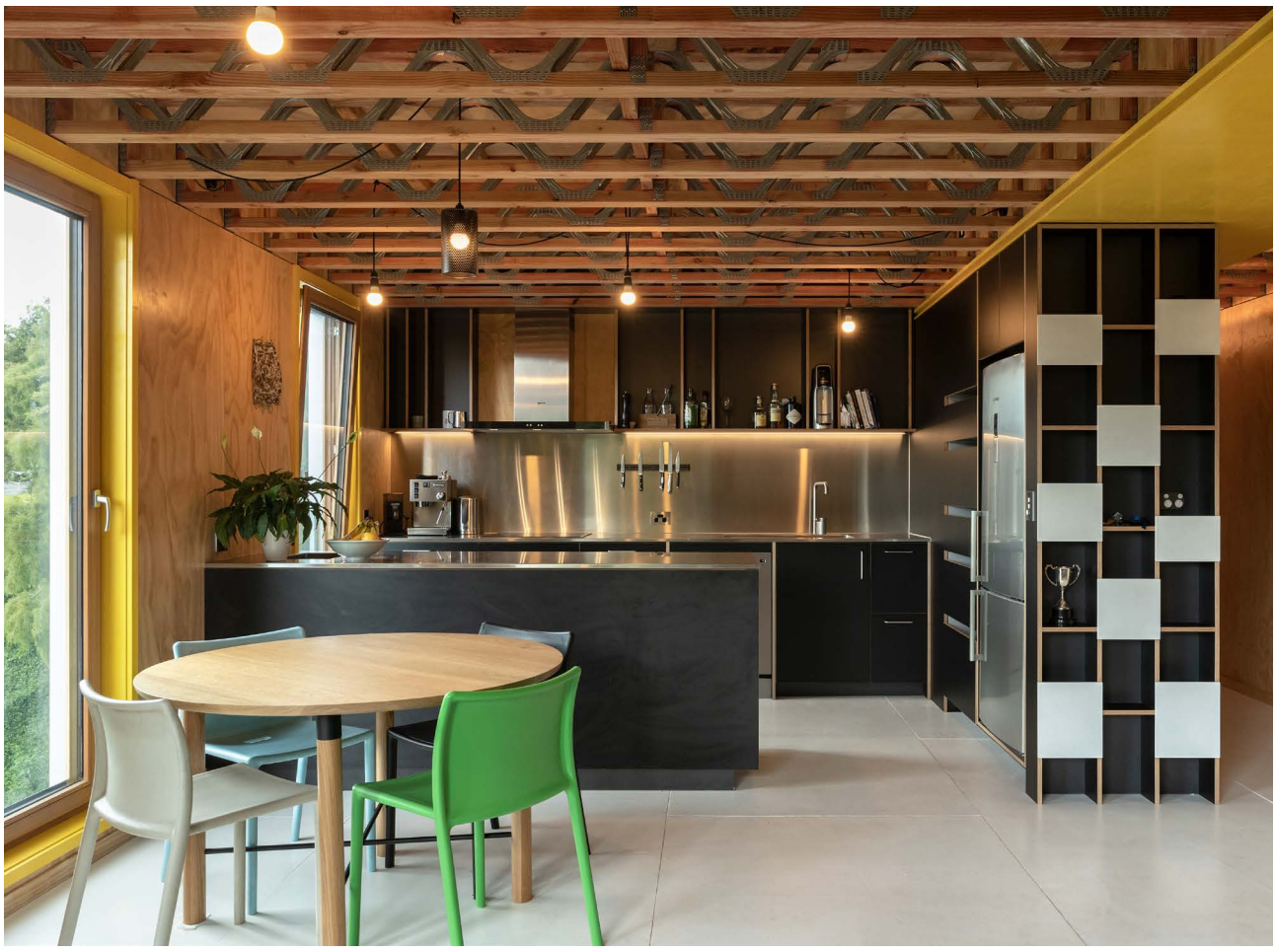
Maclean says the family has taken a while to adjust to the interior temperatures coming from living in a typical NZ house, discarding woollen jerseys for t-shirts and shorts even through the winter months, and swapping blankets for sheets on beds.

Inside, the structure of the intermediate floor is exposed to give more height to the space under it, with service lines (waste water/ventilation ducting) carefully concealed behind a partial floating ceiling aligned with interior cabinetry. Interior finishes are warm and welcoming, with prominent use of NZ pine plywood.

Outside, the house's striking exterior cladding is Zincalume corrugate, which gives a crisp juxtaposition amongst the green surroundings, while the yellow highlights on the exterior and interior are a visual salute to the Kowhai tree flower.

The Macleans have lived in the house for a year now, and thoroughly enjoy its various spaces, compactness, connection to the exterior, quietness, thermal comfort, and of course the tailored view from the main room to the kowhai tree.

Designed by Maclean and built by Stevenson & Williams, the house was certified by passive house certifier Jason Quinn as a 'passive house classic' in June 2018.





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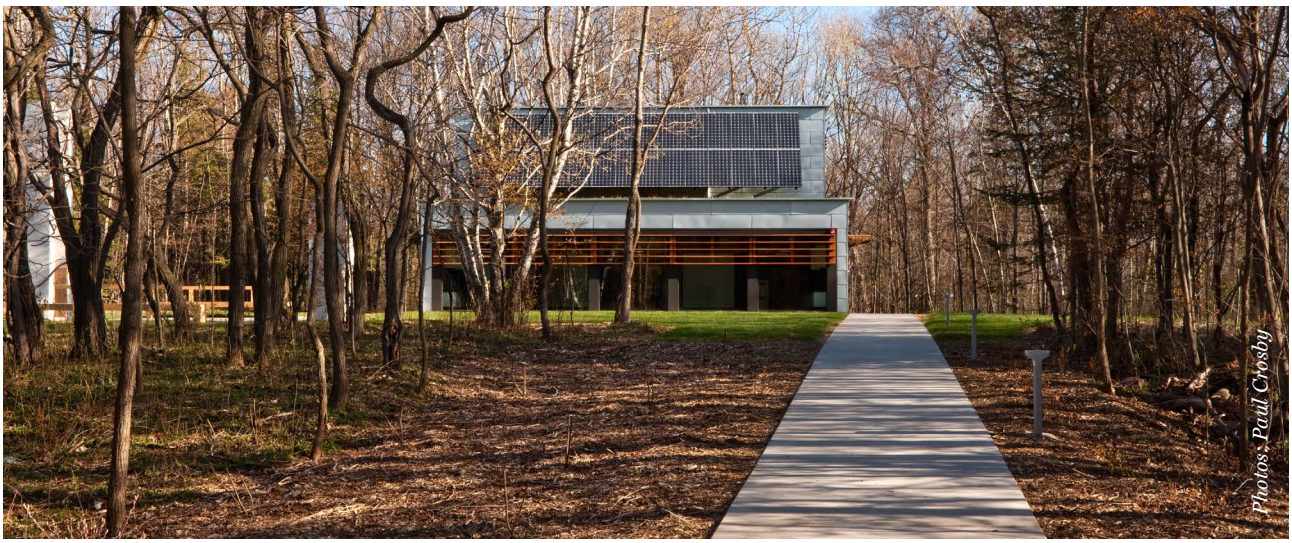
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BAGLEY OUTDOOR CLASSROOM, UNIVERSITY OF MINNESOTA, DULUTH

Situated between the shores of Lake Superior, the city of Duluth and the great forests of northern Minnesota, Bagley Outdoor Classroom is uniquely positioned for ecological field research into this region's unique habitats.

Bagley is a 50-acre nature preserve located on the UM campus. It contains rich boreal forest, trout streams and abundant wildlife, making it a perfect ecological microcosm for field study. For years, however, students studying or conducting research here had no permanent facilities to accommodate their needs.

But when an old volleyball court on the edge of the reserve fell into disuse, it presented an opportunity to provide students with a permanent base for their fieldwork. Situated in such a special place, the building was always going to need to be quite special, too.

Designed jointly by architects Carly Coulson and David Salmela, the finished building — completed in 2010 — provides a unique space from which students can observe the passage of time, of seasons, of weather and of wildlife. The finished Bagley Outdoor Classroom functions as exactly that — a classroom — but also as a shelter, laboratory, chapel, gathering hall and observation facility.

"It is transformed hourly for different functions but maintains an order and serenity, even when overflowing with activity," says Coulson. There is a flexible assembly room facing south, while toilets, storage and a wet lab face north.

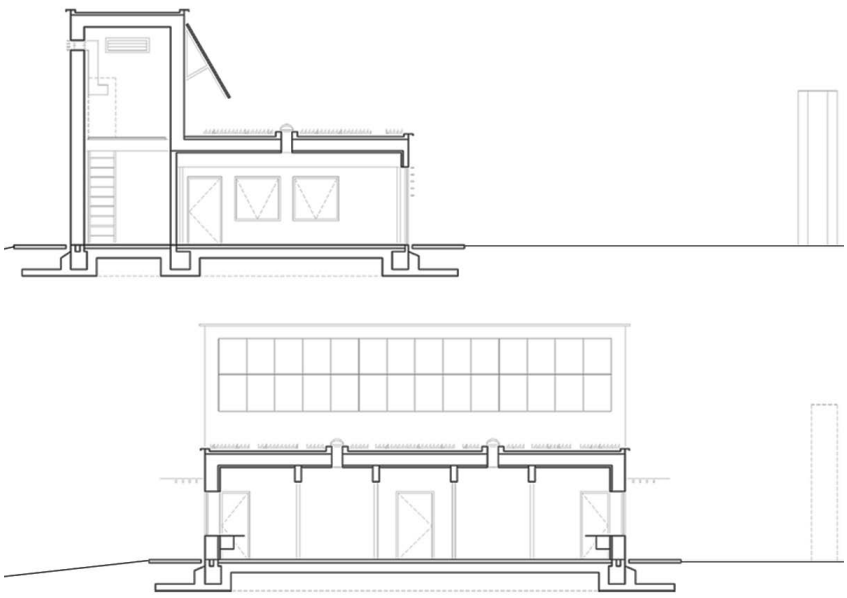
"Sustainability is invisible, integrated, elemental," she adds. Indeed, the building is both LEED platinum certified and built to the passive house standard (though not certified to that benchmark). It is built from locally-made structural insulated panels that are packed with recycled foam insulation, and also features a 6kW rooftop solar photovoltaic array.

But sustainability on the site went much further than just energy. First, there was deep attention to cutting construction waste (it was reduced by 89%, the designers say). All scrap EPS from the site was returned to the manufacturer to be recycled again, for example. Meanwhile, a maintenance-free exterior zinc cladding was salvaged from a project in Minneapolis and reused for the building.

There was also special attention paid to conserving water: toilets boast a vacuum-flush and composting system that uses tiny quantities of water, while the compost is then used for campus landscaping. There's also a drought-tolerant green roof planted in sedums and chives that changes colour with the seasons — and which absorbs stormwater, provides extra insulation, and increases habitat.

All of which put Bagley, completed almost ten years ago now, way out the front of the sustainable building curve.





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NEWS

New housing should be to passive house standard — Climate Change Committee

Words by Kate de Selincourt

The UK's official climate change advisor has called on the government to tighten energy efficiency standards for new housing to bring them down, or close to, passive house standard.

The call from the Committee on Climate Change is more ambitious than the Government's own 2018 clean growth strategy, which the committee dismissed as "out of step with the urgent timeline needed". The committee has also called for gas heating to be phased out of new builds within six years, giving way to heat pumps. In its review 'UK housing: fit for the future?', the committee expressed dismay that government ambition appeared to be in retreat.

The report said: "Ambitious standards were set under the Zero Carbon Homes policy which would have come into force in 2016, had they not been cancelled. The UK is also signed up to delivering nearly zero energy homes by 2021 under the Energy Performance [of] Buildings directive, although the status of this is now unclear."

Indeed, a circular letter sent out by the Ministry of Housing in January stated that, "following the existing Building Regulations guidance and relevant Government procurement policies would be an adequate way to demonstrate compliance with the nearly zero energy buildings requirement".

This is clearly out of step with the European Commission's advice that new homes should have a maximum primary energy demand of 45 kWh/m^2/yr in order to meet the NZEB standard. It is also in stark contrast to other EU countries that have significantly tightened new build standards to meet the directive, and demonstrates a lax approach that may be driven by the UK's likely imminent exit from the European Union.

The Committee on Climate Change said: "The Government should act now to set an ambitious trajectory of standards, regulations and targets for new homes, ensuring they are fit for 2050 and beyond." It also called for a "near complete decarbonisation of how we heat our homes". It also stated: "Our homes must be low-carbon, energy efficient, have safe moisture levels, excellent indoor environmental quality, and be climate resilient. This is not happening at present."

New homes must be built to tight specifications to avoid expensive retrofit later, the committee said. "New build homes should deliver ultra-high levels of energy efficiency as soon as possible, and by 2025 at the latest. This should be consistent with a space heat demand of 15-20 kWh/m^2/yr." The passive house standard is 15 kWh/m^2/yr.

The committee commissioned analysis which showed that building to these standards ought only to cost around £4,800 extra per home. By contrast, carrying on building homes the way we do now would incur unaffordable retrofit costs in order to meet climate targets — five times more than getting it right in the first place, the committee says.

In a report also published in February, the Energy and Climate Intelligence Unit (ECIU) pointed out that occupants of new homes could be saving more than £200 per year on their energy bills if the properties had been built to the ditched Zero Carbon Homes standard.

As well as the lack of ambition in the building regulations, the Committee on Climate Change was damning about the performance gap between design and real-world energy efficiency in new homes.

A committee spokeswoman was reported by the Carbon Brief website comparing underperforming homes to the Volkswagen emissions scandal: "[homebuyers] are being told they're getting really well insulated, sustainable homes [but] these homes are nothing like as good as they should be…to me, this is a scandal of Volkswagen proportions."

The committee refers to Dame Judith's Hackitt's post-Grenfell report on the construction industry, noting the report "highlighted the systemic compliance issues in the current Building Standards regime," and quoting Dame Judith's words: "the whole system of regulation… is not fit for purpose, leaving room for those who want to take shortcuts to do so."

The committee makes a clear recommendation: "Overhaul the compliance and enforcement framework so that it ...provides transparent information and a clear audit trail, with effective oversight and sanctions."

"Building control enforcement should also be adequately funded as a matter of urgency," it adds. To crack down on the performance gap the committee wants actual, not merely estimated, building performance to be regulated.

"'As-built' performance should be formally integrated into the standards and enforcement framework. It is critical that stronger compliance and enforcement procedures, with greater levels of inspection and heavy penalties where appropriate, are in place," it says.

The committee also states: "From 2025 at the latest, no new homes should be connected to the gas grid. They should instead be heated through low carbon sources, have ultra-high levels of energy efficiency alongside appropriate ventilation and, where possible, be timber-framed."

Decarbonisation requires a dramatic reduction in the heat energy required by our homes, and retrofit of older homes is essential in order to make them 'heat pump ready'. This requires much more active participation in the transformation by the government, the committee says. ■

Additional reporting by Jeff Colley & Lenny Antonelli

Table 1.1. Costs of designing in measures for a new home at the outset, relative to trying to achieve the same outcomes later

Measure	Cost - new build	Cost - retrofit (equivalent outcome)
Building a home with an air source heat pump and ultra-high levels of fabric efficiency (equivalent to a space heat demand of 15 kWh/m^2/yr)	£4,800	£26,300

The committee calculated that the extra cost of building to a 15 kWh/m^2/yr standard as opposed to the current building regs level would be around £4,800 per dwelling. These figures call into question the argument that building to higher standards is genuinely unaffordable.

Phase one complete at UK's largest passive scheme

The first phase of Agar Grove, the UK's largest passive house development, has now been completed for the London Borough of Camden. Hawkins\Brown acted as lead architect on the project, while Architype acted as passive house delivery architect for the first phase of the scheme, which provides 38 homes that are all socially rented to existing estate tenants.

Once complete, the scheme will deliver 500 energy efficient, affordable homes, making it the largest passive house development in the UK. Agar Grove is part of the council's community investment programme and aims to promote a 'fabric-first' approach to increase energy performance.

A large majority of the apartments are dual aspect with bedrooms elevated above ground floor level, with living spaces benefitting from the south-facing aspect, a balcony running the full width of the façade, and panoramic views of central London from the middle levels and above.

Natural light and open spaces are designed to make the homes feel welcoming and spacious. Double height communal entrances offer a direct view through the building to the residents' garden on entering. Stairwells and corridors are naturally lit and ventilated, with a touch of colour and pattern.

Located north east of Camden Town on a site adjacent to two railway lines, the original modernist estate dates from 1966. The site comprised 249 social-rented homes arranged in a series of low-rise blocks clustered around an eighteen-storey tower, served by its own shop and café. The estate's layout and housing stock had become inefficient, outdated and disconnected from the wider city.

The new master plan is based upon the traditional concept of 'streets and squares' with an emphasis on creating liveable spaces between homes, and improving pedestrian routes across the site. A range of house types has been introduced including family terrace housing and maisonettes with gardens, as well as lateral flats with balconies.

Working with Mae and Grant Associates, Hawkins\Brown developed the initial proposals in collaboration with residents for the redevelopment of Agar Grove. Seth Rutt, Partner, Hawkins\Brown said: "This scheme is a great example of how good community consultation can add value to a project. The brief and principle of development were established in open dialogue with all residents, to ensure as many people as possible have their opinions heard." ■



(above) The south façade of block A of Agar Grove, with deep balconies to protect against high angle summer sun while maximising winter solar gain, and decorative metalwork doubling as external shading against late afternoon/evening sun.

Local authorities declare climate emergency

Words by Kate de Selincourt

The government is facing new pressure from over 30 local authorities, including several major towns and cities, who have declared a 'climate emergency' and pledged to work to become 'carbon neutral' within timescales as short as 11 years.

The local authorities are all calling on the government to facilitate these goals. Many of the motions have been passed unanimously, meaning that councillors of every political affiliation have come together to back the motions.

Councils now have to work out how to achieve this. Manchester City Council's executive member for the environment, planning and transport, Councillor Angeliki Stogia, told Passive House Plus: "We are currently in the early stages of developing a new approach to zero carbon construction."

Passive house was one option being explored: "One Manchester [a large housing association in the city] have been one of the first organisations to trial 'passive house' energy efficiency standards locally. Passive house is one of several available definitions of 'zero carbon' and we will be exploring with partners how [to] further pilot projects to test key principles."

Meanwhile, Joanne Wheeler of the UK Green Building Council told Passive House Plus that a number of local authorities are also bringing in policies requiring new housing to perform at levels better than current minimum regulations. Reading, for example, is working to adopt a policy echoing the Greater London Authority's guidance for 'zero carbon' homes.

The UKGBC's "Policy Playbook" lists a number of other authorities working to similar goals and reports that Brighton & Hove, Ipswich and Cambridge have already adopted policies. These three all require a 19% reduction in emissions beyond the current regulations (equivalent to the old Code for Sustainable Homes Level 4) for larger developments.

Fabric efficiency seems to come second to renewables, however — for example, Ipswich requires "15% of energy requirements from decentralised and renewable or low-carbon sources", and energy efficiency is required only if the additional renewables can be shown to be non-viable. ■

Bristol project gets 'passive house plus' cert



Photo by Alan Russell

Greenheart Sustainable Construction (Greenheart) has achieved a passive house plus certification on its latest project near Bristol, one of only a handful of buildings in the UK to achieve the standard. The benchmark is awarded to buildings that meet passive house standards of energy efficiency but also generate 60 kWh per metre square of renewable energy each year.

The pioneering home was a collaboration between Greenheart, S2 Architects and Sadler Consulting, and achieved an airtightness score of 0.35ACH at 50 Pascals.

The timber frame was built on site from 360mm deep I-beams, with a simple trussed roof. It also includes a whole roof integrated 7.3KW PV system, a Mitsubishi air source heat pump with thermal store and the latest Powerwall 2 Tesla battery for storage, enabling the building to be largely self-sufficient in heating and hot water. Data can be monitored by the clients via an app on a smartphone, laptop or tablet.

The external walls were insulated with Warmcel, clad in 80mm Pavatex and rendered in a self-coloured Baumit render, the porch area clad in sweet chestnut. The loggia is built of Douglas Fir with solar control glass from Pilkington to mitigate some of the solar gain through the large sliding window. All windows and external doors were passive house certified, a combination of Rationel and Green Building Store units, plus Fakro triple glazed roof lights.

Greenheart project manager Malcolm McMahon commented: "Although we have worked on many passive house projects, this was the first passive house plus house and the team enjoyed the additional challenges required to make the house a success. The client's enthusiasm and passion for sustainability made the project all the more enjoyable."

Energy consultant Piers Sadler said: "The combination of passive house with efficient electric heating in the form of an air source heat pump and solar electricity generation with battery storage, reflects the future for low energy building as it minimises both overall and peak electricity demand." ■

New UK homes use six times more heat than passive houses

Words by Kate de Selincourt

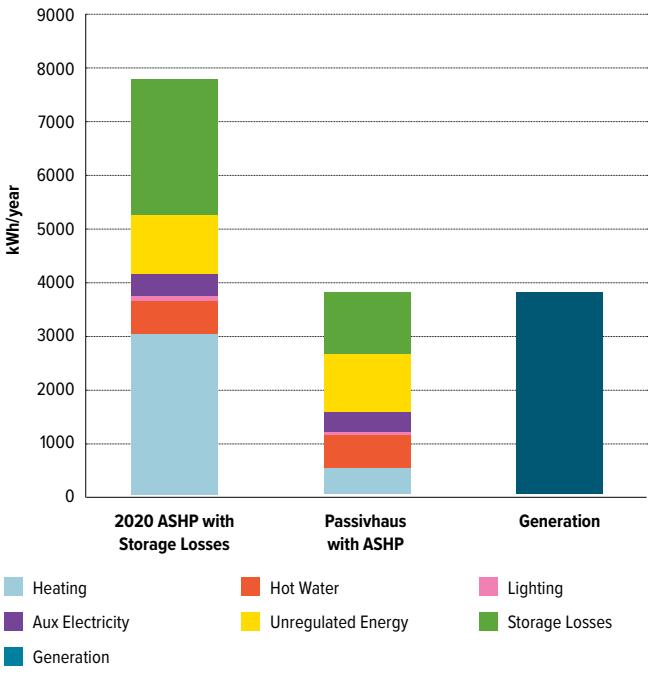
A new publication from the Passivhaus Trust, 'Passivhaus: the route to zero carbon?', highlights the energy cost of the performance gap in typical new homes built to UK building regulations, and contrasts this with the recorded performance of homes built to the passive house standard.

By looking at a set of EPCs for houses completed in 2015/16, then multiplying the expected heating energy use by an in-use factor derived from real-world studies* of as-built performance, the trust calculated that a typical new-build home built to the most recent (2013) building regulations, to typical UK standards, would use approximately six times as much energy for heating, as would an equivalent passive house.

Assuming identical energy consumption for other regulated and unregulated energy, the total energy demand of a typical new-build is around double that of a passive house, with enormous implications for the ability to supply these homes with low carbon energy and low carbon heat.

To download the report, visit **http://bit.ly/PHZeroCarbon**

*See for example work by Leeds Beckett University, Innovate UK and the University of Bath – see Passivhaus Trust paper for full references. Research has demonstrated that the heating energy consumption of passive house dwellings averages at very close to the target 15kWh/m²/yr, while for mainstream construction the performance gap can be as high as 150% above the target. ■



(above) A comparison of the total energy demand of a passive house vs a typical UK new home. Graph: Passivhaus Trust

Social landlords not prepared for climate change — report

A new report has found significant action needs to be taken by social housing landlords in order to prepare for the worst effects of climate change.

The report, 'Housing 2050: How UK social housing can meet the challenge of climate change', sets out a list of actions that need to be carried out to ensure the targets set for CO2 emissions in 2050 are met by social housing providers.

The research was carried out by Sustainable Homes, a non-profit research and policy group established by Hastoe Housing.

The report found that current social housing is not fit for 2050, and nor will it be if business planning continues on its current trajectory. It also found that, given the current financial planning cycle for social housing landlords is 30 years, financial plans need to be reviewed now in order to ensure they are still viable in the context of climate change.

The research found that landlords are not on track to reach an average EPC score of 86 (band D), and that there is an over-reliance on gas and a lack of investment in heat recovery systems, renewables and infrastructure for electric vehicles. It also found that climate resilience measures are perceived as low priority by social landlords.

The report lists a range of actions that need to be taken. These include establishing higher building standards, educating and upskilling staff in energy efficiency measures and new technologies, prioritising measures to tackle flooding and overheating, seeking public-private partnerships for low-carbon communal heating systems, and installing electric vehicle infrastructure.

Richard Lupo, sustainability consultant and author of the report, said: "The science states that we must make significant reductions in CO2 emissions by 2050 in order to avoid the worst impacts of climate change. Typical financial planning cycles of 30 years for social landlords means that it is vital to start planning now, before getting locked into financially-crippling strategies."

"This research provides a snapshot of the current state of UK social housing. It highlights some good practice but also points to actions that need to be taken right now. I remain optimistic especially because new financial models are emerging which will help pay for the necessary improvements."

Housing 2050 is based on research involving a number of participating housing providers, with additional support provided by Ecuity and the Committee on Climate Change. To read the full report see **www.sustainablehomes.co.uk**. ■

Five pioneering low carbon housing projects secured for 'Building for 2050' research



Five pioneering low carbon housing projects have signed up to be part of the Building for 2050 research project, funded by the Department for Business, Energy and Industrial Strategy (BEIS). The project, launched at the Futurebuild conference in London, will help shape future UK policy on delivering low carbon homes in England and Wales.

The project will review different ways of delivering low cost, low carbon homes and monitor their performance in use. The research team will work closely with the case study teams to understand the designs and any issues encountered and they will engage with residents to capture their views. This experience will inform ways to increase the widespread construction and uptake of low carbon homes in England and Wales by 2050.

The five housing developments comprise:

- Active Homes in Neath, S Wales: a small development of 16 social rent homes by housing association Pobl Group. They are designed as mini power stations using battery technology, heat pumps and solar PV to generate around 80% of the energy they consume and slash tenants' energy bills by at least 50%;
- Rayne Park, Norwich is one of the passive house developments in the UK. The Norwich Regeneration scheme will see 112 of the 172 new homes certified to the passive house standard.
- ETOPIA Homes, Corby is a scheme of 47 modular homes that are equipped with energy saving technology - a combined solar photovoltaic and thermal panel, heat pump, inter-seasonal storage and smart home equipment - to deliver a net zero carbon standard on site;
- Marmalade Lane, Cambridge is a custom-built cohousing community. Made up of 42 custom build homes complemented by first-class shared facilities, Marmalade Lane has been designed with a fabric-first approach delivered with offsite manufactured closed timber panels supplied by Swedish builder Trivselhus, combined with heat pumps to supply heating and hot water;
- Tallack Road, Leyton comprises a mix of 50 new affordable and private flats and houses. The development, delivered under the London plan policy for low carbon homes, is the first to use a large-scale communal Air Source Heat Pump feeding an ambient temperature heat network and individual heat pumps, together with solar photovoltaic panels to provide a predicted 57% reduction in carbon emissions on site.

Building for 2050 is being managed by an AECOM-led research team, drawing on AECOM's technical and social research expertise, and includes architects, Pollard Thomas Edwards; building performance experts, Fourwalls and low carbon technology specialist, Delta-ee. ■

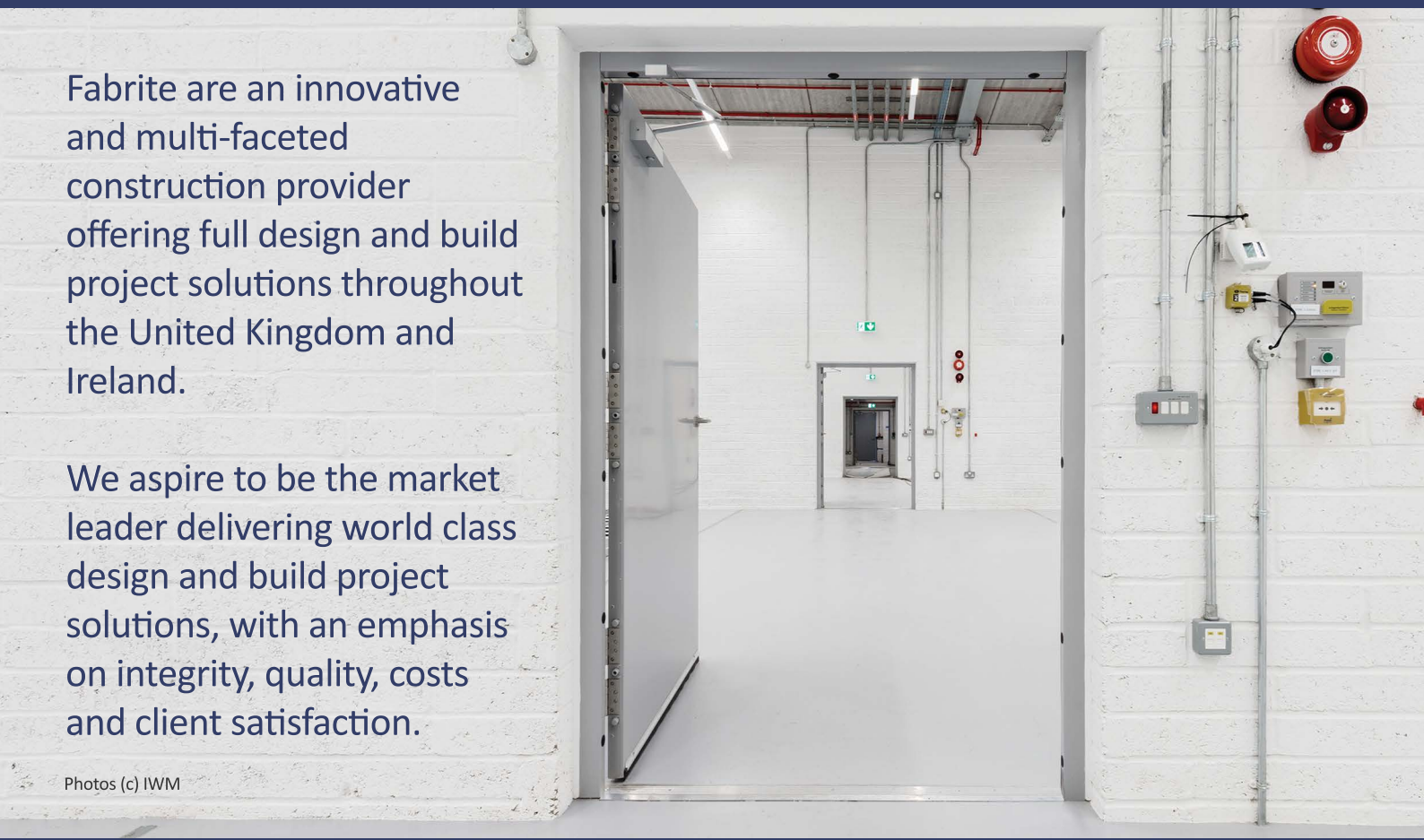
(above left) Marmalade Lane Cambridge, a custom-built cohousing community.

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Imperial War Museums archive breaks airtightness record

A state-of-the-art archive building in Cambridgeshire, which has been built to house Imperial War Museums' (IWM) rich paper collection, has registered the best airtightness test result ever recorded in the UK – and perhaps, the world.

The building at IWM Duxford – one of five IWM museums and historic sites covering war and conflict from the First World War to the present day – has been designed to meet the passive house standard, allowing IWM's documents collection to be preserved in the best possible conditions.

The 1,238 sqm building, which has just come through practical completion, achieved a final airtightness score of 0.03 air changes per hour (ACH) at 50 Pascals – making the building 20 times tighter than the target for certified passive buildings, and approximately 200 times tighter than current UK requirements for non-domestic buildings. The Passive House Institute is aware of one other project that has achieved 0.03 ACH – but none lower.

The project benefited from bona fide passive house expertise on the design team, led by architects Architype and passive house consultant Nick Grant of Elemental Solutions. The result is made all the more remarkable by the fact that although main contractors Fabrite had done airtightness work before, they were new to passive house airtightness standards – and by all accounts rose to the challenge.

Architype associate Gareth Selby worked on the project from early design stage, and his colleague Meital Ben Dayan came on as project architect from stage three onwards. The building started on site in May 2018. According to Selby, a design approach that focused on simplicity and buildability was key.

"At stage 4 when we were detailing it was one simple layer – originally to be of plaster – and then at the ceiling was one simple layer of concrete." This kind of stripped back simplicity is something Nick Grant – a champion of value engineering in the truest sense, rather than the more cynical practices that too often pass for it - is renowned for. Architype and Grant had worked together on many other projects, and IWM Duxford draws heavily on the lessons learned from the repository section of Hereford Archive and Records Centre – essentially a wet plastered concrete box, connected to a thermally independent timber frame section.

At Duxford, the walls consist of loadbearing 440mm blocks laid on their side, with the airtight layer on the room side – with an insulation layer and steel cladding externally. Grant suggested substituting the wet plastered finish with Blowerproof, an innovative paint-on airtightness membrane which had recently gained BBA certification. As Blowerproof is available in a white finish, the decision was taken to leave the airtight layer exposed. But the new product first had to be submitted to the scrutiny of a client with exacting standards: IWM is duty bound to take an unusually long-term view, given the need to develop and care for its collection for future generations.

The organisation subjected a sample of Blowerproof to an Oddy Test – a procedure developed to test materials for safety in and around art objects, and specifically for trace amounts of chemicals and pollutants that may offgas and harm objects over time. According to Selby, the product passed with flying colours.

Engagement from the main contractor is critical to delivering airtightness on iste, and both Selby and Grant are effusive with praise for Fabrite, whose contracts manager Nigel Johnston and site manager Darren Fraser took charge of delivering the airtightness on site. "It was conveyed to me very early, this building hinges on achieving a good airtightness score," said Fraser. This meant "making sure the same enthusiasm and attention to detail was carried out on site, monitoring the attention to detail and making sure everyone was on the same page – and chasing people around with mastic tubes."

Four coats of Blowerproof were applied by applicator UCL – two before an initial airtightness test, and another two after. One compromising factor was doors: four hour fire rated doors and gas blowout doors, which weren't available to passive house specs. "We had a huge leakage from door frames," said Fraser. "Before the test we noticed the door frame was hollow, spoke to the supplier, filled the frame with Rockwool to try to prevent air leakage, and put lots of mastic around the frame."

According to Selby, the other tricky areas from a detailing perspective were the connections between the roof and the wall. Again, the design team drew from the experience on Hereford Archive. The roof structure consists of precast hollowcore concrete planks between downstand beams. Little junctions between planks, and gaps where the hollowcore plank ends met the walls, required particular care on site.

"You become a bit obsessive," said Fraser, who says that enthusiasm, planning and communication were key to the project's success. "By considering the tricky junction details before work on site started, information was readily available. The message and principles of passive house builds were well communicated to Fabrite as contractors and in turn passed on to site. The project was a great success and an extremely enjoyable experience. I would love to work with this team on future projects." ■

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The Jodrell Bank grand challenge

During a speech last year Theresa May challenged the construction industry to halve the energy use of new buildings, and to halve the cost of retrofit. But we already know how to meet these challenges, writes Peter Rickaby, and much more difficult tasks lie ahead.

At a conference in the wake of the 1982 OPEC oil embargo, the American engineer Fred Dubin posed a question: "How would your buildings fare if they had to run on half the energy you designed them to use?".

This question was not a response to climate change, which was not yet on the agenda (although it lurked in the wings). It was a challenge about the robustness of buildings against an uncertain political future. It provoked bewilderment, and much panicky talk of office buildings being rendered uninhabitable by lack of air conditioning, and even of freezing in the dark.

Thirty-five years later, energy performance standards have improved, and most new buildings probably do use half the energy they would have used in the early 1980s. For existing buildings, the picture is less clear – some refurbishments have halved energy use, but many have not.

> The difficult part will be persuading the building industry to accept new standards.

But we are no longer bewildered: we know how to halve energy use, even if we don't always rise to the challenge. The trick is to avoid designing energy demand into the form and fabric of buildings, and then needing to use fuel to engineer it out. Instead, use the form and fabric of the building to reduce energy demand, then satisfy the residual demand efficiently – which is of course a principle of the passive house standard.

Recently in the UK, a similar challenge has been presented. The Jodrell Bank grand challenge (named for a speech Theresa May delivered at the famous radio telescope in May 2018) has been embedded in the government's 'Clean Growth Strategy'. The challenge is to use new technologies and modern construction practices to at least halve the energy use of new buildings by 2030 — and to halve the cost of reaching the same standard in existing buildings too.

Note that for existing buildings the challenge is only to halve the cost of halving energy use, not to achieve the reduction.

How might we meet this challenge? It seems to me that for the new build sector, for both domestic and non-domestic buildings, the challenge is technically trivial. If we take the energy performance standards in the current building regulations (in the UK or Ireland) as the baseline, then adopting the passive house standard, combined with some renewables, would easily get us there. We have many domestic buildings, and some big non-domestic ones, that demonstrate this. We could be more ambitious and adopt the European NZEB standard.

However, the difficult part will be persuading the building industry to accept new standards, and to deliver them consistently. This requires a change of attitude in the construction industry (which in the UK always pushes back against proposed standards) and extensive training of designers and builders, to provide the necessary skills.

Here again, the passive house standard is part of the solution: the 'performance gap' between designed and actual energy use is really an attention to detail deficit, and one of the strengths of the passive house standard and its design software, PHPP, is that they tell us which details need our attention, both in design and on site.

Perhaps Ireland, with higher energy standards and longer experience of passive house, will do better than the UK in this respect. On a visit to new housing developments around Dublin last year, I was impressed not only by the designs but also by the quality of the work on site, and the pride taken in it by construction teams.

For existing buildings, the Jodrell Bank grand challenge is more demanding, and more important. Over 80% of the buildings that exist today will be in use in 2050, so if we are to meet our emissions targets in either country, big retrofit programmes are needed and reducing cost will be essential.

Nearly ten years ago, the UK's Retrofit for the Future programme suggested that the average cost of one-off deep retrofit (80% emissions reduction) in social housing was between £80,000 and £90,000 (the Jodrell Bank grand challenge baseline), and that economies of scale might reduce it to £50,000. We also learned that the relationship between retrofit cost and emissions reduction is such that lowering the on-site emissions reduction target from 80% to 50% halves the retrofit cost.

Subsequent analyses of many housing stocks have confirmed that for 50% emissions reduction the average scale retrofit cost is less than £25,000, but the range is large: from less than £10,000 to more than £50,000. There are also many traditional and historic buildings where reducing emissions by 50% is not possible, so we will have to do better elsewhere, to compensate.

The Greater London Authority's retrofit programmes are teaching us how to identify the low-hanging fruit: the homes that can be improved at least cost. SEAI's deep retrofit programme in Ireland is teaching us technical and financial lessons about how to get houses to EPC/BER band A2.

What can we conclude about the Jodrell Bank grand challenge? It's not much of a challenge: we already know how to achieve the required standard, and we are well on the way to achieving the cost target for existing dwellings. So, as they say in Ireland: "it's not that grand!" The difficult parts will be introducing better standards to building regulations, changing attitudes, improving skills and implementing retrofit at scale. ■

Dr Peter Rickaby is an independent energy and sustainability consultant, chair of the BSI retrofit standards task group, and principal research associate at the UK Centre for Moisture in Buildings at University College London.



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Double talk: a brief history of insulated glazing

In his latest column on the history of low energy building in the 20th century, Dr Marc Ó Riain charts the surprisingly fascinating history of double glazing.

Segueing from articles on US solar housing in the 1950s, the mass production of double glazing became an important element in low energy housing design thereafter. Few realise that double glazing was initially patented 154 years ago but did not take off till the mid-20th century. I felt it important to delve into the development of this technology before returning to the historical development of solar housing in the 20th century in my next article.

Although volcanic obsidian glass was used in decorative objects and weapons as early as 5,000 BC by the Phoenicians, man-made glass would not find any level of true success until the development of the blow pipe by Syrian craftsmen in the first century AD, which saw the Romans become the first to adopt glass for use in windows.

Glass was blown, spun, cut and flattened into a disc, laid onto an iron tray and then cut into small plates for use as windows, essentially to retain heat. Early 'crown glass' was often uneven and unclear because the glass cooled too quickly for the plate to be flattened and thus needed to be ground and polished to produce greater transparency. This made glass very expensive to produce.

The migration of Venetian glass makers to northern Europe in the late 15th century underpinned the development of clear "polished plate" glass in 16th century France, a more refined clearer product than its predecessors. Although leaded glass was developed in England in 1674, making glass easier to work and flatten for longer periods, the Crown's policy of "daylight robbery" (window tax) from 1696 to 1851 would effectively retard the wider application of glass in windows during this period.

The fortuitous confluence of "cylinder sheet" glass technology in 1834 — which reduced production costs and allowed for larger panes to be produced — with a more forgiving tax regime resulted in a boon for the window industry thereafter.

Stetson's patented doubling glazing system for sash windows in 1865 was designed to reduce heat loss and noise transfer. His patent was a simple construction with a timber spacer bar separating two sheets of glass by a narrow cavity, adhered with putty (whiting and oil) which took a few weeks to harden before transport. Perhaps because of the punitive costs of glazing, Stetson's patent did not become a commercial success, or perhaps it was before its time.

In October 1934, Charles D Haven patented a sealed double glazed unit called 'Thermopane' which reduced heat transfer and prevented interstitial glazing condensation. Haven realised that there would be a differential in expansion and contraction between the interior and exterior glass sheets causing a strain on the bonding and spacer material, sufficient to break down the bond with the sealing coating. Haven favoured dehydrating the air gap, rather than filling it with an inert gas, and then hermitically sealing it to avoid product failure. The promotion of Thermopane and 'solar housing' by the company Libbey Owens Ford resulted in double glazing becoming very successful through the 1950s and 60s in the US.

Although Yorke (1934) recorded double glazed sliding doors, manufactured in the UK, in Lois Welzenbacher's Schultz house (1928), only 10% of UK housing would have double glazing before the 1973 oil crisis. Pilkington's development of float glass in 1957, formed on a molten layer of tin, flattening under its own weight, and eliminating the need for polishing, would result in a further cost reduction. The introduction of U-value limits (an average of 1.8 W/m2K between windows and walls) in the post oil crisis UK, and the reduced cost of float glazing, created an optimal market demand for double glazing to take off this side of the pond.

It was found that early aluminum framed double glazing experienced condensation, often resulting in rotting timber sills. This technology was widely replaced in the 1980s by uPVC double glazing. This material now represents 50% of the window market, followed by wood and aluminum both at 25% of the sector. Of course, we now have access to triple and quad glazed windows, filled with a variety of inert gases and also available in alu-clad with whole window U-values below 0.75. By 2012, 80% of UK housing had double glazing. As this double glazing comes to the end of its lifespan it is still very expensive to replace. Is it time for another technological leap or for government policy to step in? ■



(above) Crown glass manufactured in 1404. Photo by Friedrich Böhringer.

Dr Marc Ó Riain is a lecturer at the Department of Architecture at Cork Institute of Technology, one of the founding editors of Iterations design research journal and practice review, a former president of the Institute of Designers in Ireland, and has completed a PhD in low energy building retrofit, realising Ireland's first commercial NZEB retrofit in 2013.



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Building: 190sqm timber frame passive house

Location: Colwall, Malvern, Worcestershire

Completed: November 2016

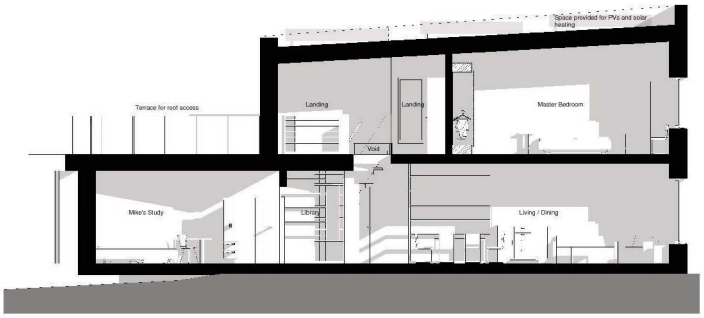
Standard: Passive house certified



WOODLAND WONDER

Hiding in woodland in an area of outstanding natural beauty, the Fishleys passive house manages to be both strikingly contemporary yet deeply sensitive to its rural setting. It also boasts a masterfully crafted timber frame structure with one of the best airtightness results this magazine has ever published.

Words by David W Smith





Despite its modern appearance, the three-bedroom Fishleys passive house won planning permission on the rural Herefordshire-Worcestershire border largely for its sustainable credentials and sensitive design. From the outset, the design embraced the site's concealed position nestled in woodland in the village of Colwall, located within the Malvern Hills area of outstanding natural beauty.

"The owners wanted it to feel like a retreat in the woods as they both love woodland very much, so it has no relationship with the road. We tested views from all around the site and it was well-sheltered by the woods," says architect Matt Hayes of leading passive house design firm Architype.

"But we also designed it to capture the stunning views across to British Camp, an iron age hill fort that is one of the highest points in the Malvern Hills. One other important design element was to make the most of the solar gain from the south."

To make sure the house blended in with the woodland, the architects tested different cladding materials before settling on Douglas fir. Matt says the "vertical feel" of the cladding blends in well with the birch, ash and oak trees in the woodland. Meanwhile the small 'retreat' section of the house has a much smaller mass that cantilevers into the woods so "it feels like it's tucked into this cluster of silver birches".

Hayes continues: "The house is seamlessly bedded into the woods and the route through the woods from the road is impressive, I think. As you get closer to the house, you see the striking red door set against the green of the woods. The timber cladding has had a natural oil stain that gives it a grey-silver hue that will eventually wear off as all the timber is silvered uniformly."

Alongside the woodland niche and the spectacular views, the owners Liz and Mike Hill enjoy the quality of life inside their passive house. "We're very happy here. Last summer, when the temperatures were so high, we had a nice comfortable working temperature all day," says Mike.

"It never exceeded the temperature outside until around 10pm in the evening. We're also passionate about ecology, growing our own food and taking care of the environment, so the passive-house lifestyle suits us."

The couple's plan, hatched back in 2015, was to dismantle a large barn on their four acres of land, auction it on eBay, then replace it with a passive house. They also knocked the old 1960s house they had been living in on the site.

They then approached local passive house specialist Architype and were given a series of design options to choose from for the house. They ended up surprising themselves by going with a flat roof design rather than a more traditional style. "Although we stipulated that we didn't want a boxy, flat roof, the more we looked at it the more we liked it," says Mike.

From the start, Mike and Liz were closely involved in the entire process. They had a number of requirements that Architype had to incorporate into the design. Both are software specialists who sometimes work from home, so they needed two study rooms,

> Last summer, when the temperatures were so high, we had a nice comfortable working temperature all day.









but these rooms had to be easy to convert into double bedrooms for when their two adult children, or elderly relatives, visit.

Another requirement was that they have no intention of moving out of the area, and the house had to be easy to manage in old age. One final stipulation from Liz was to avoid the trend for open-plan living. She wanted the kitchen to be separate from the living space, ensuring noise, smells and mess were hidden away.

"We made it as efficient and flexible as possible," says Matt. "Both studies double up as guest bedrooms and one of the study areas is on the ground floor. It's next to a wet room that is designed with concealed knockout doors, so it's easily transformed into a ground-floor accessible bathroom. It means the ground floor has the potential to be turned into a bedsit with everything they need."

And though the house has no attic for storage, the architects designed deep cupboards along the corridor on the first floor, as well as a walk-through library on the way to the study.

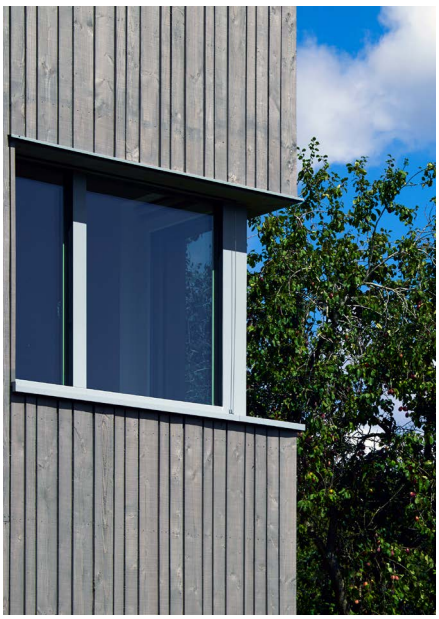
Herefordshire is fortunate to be the home base for some of the UK's most experienced practitioners of passive-house development. Hereford-based Architype has won three CIBSE building performance awards for passive house schemes and become renowned as leaders in designing buildings of all types to the standard, and many of the firm's most high-profile projects have featured in the pages of this magazine.

After a decade of building passive houses, they now make up 70% of Architype's current projects, including the UK's first passive house-certified secondary school for the London Borough of Sutton.

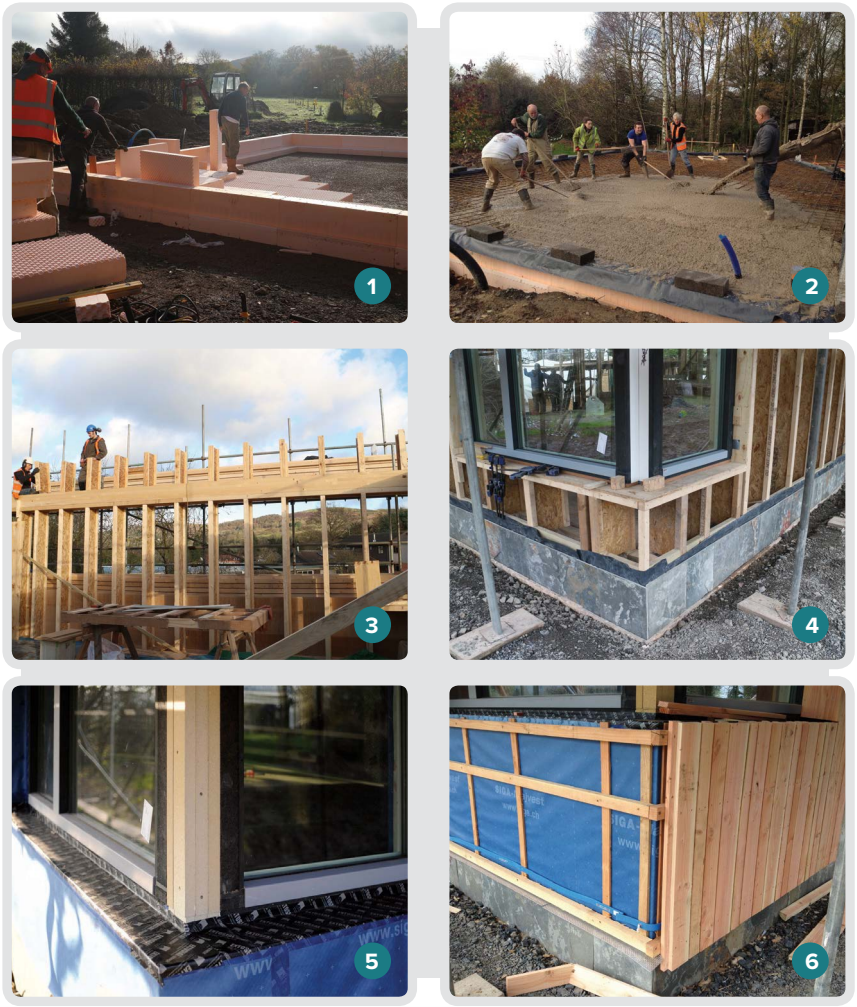
Meanwhile, the builder for Fishleys was

Photography: Matthew Ling Photography





CONSTRUCTION IN PROGRESS



1 The Isoquick EPS foundation system wraps the entire raft foundation in insulation to eliminate any thermal bridges; **2** laying the 250mm reinforced concrete slab; **3** installing I-beams for the stick-built timber frame system; **4** Green Building Store Progression windows installed into the timber frame system; **5** airtightness detailing around windows; **6** external wall build-up includes a Siga Majvest façade membrane, a 50mm ventilation zone, and 2x20mm Douglas fir cladding.

another Herefordshire-based passive house specialist, Mike Whitfield. In 2005, Whitfield was the main contractor for the Duchy of Cornwall on the conversion of two barns into Architype's office, a project that won the 2007 RIBA sustainability award. He has completed around 15 passive houses over the last decade and is now working on a low energy building to mark Prince Charles' 70th birthday.

On the Fishleys development, Whitfield took charge of the build on site after Architype had completed the plans. He liaised with the engineer and spoke almost every day with Liz, who was working from home. Whitfield suggested all kinds of small details, such as an oak door with oak latches, which added to the beauty of the home, although in other matters, the couple preferred to find their own more cost-effective options.

Groundworks lasted from summer 2015 until the end of the year and then building work began in January 2016. Whitfield's team had the whole wooden frame watertight using I-beams in March despite torrential downpours and high winds at the beginning of February. The house was waterproof after eight weeks and the couple were able to move in by November 2016.

All the framework was built on site as Whitfield prefers not to use prefabricated panels. "It's more expensive to use prefabricated as long as you have the expertise to do it efficiently yourself. But if you have inexperienced carpenters on their first passive house, a factory product might be easier," he says.

"Another reason we prefer to build it ourselves is it gives us greater flexibility to start and finish when we want. In the time we were waiting for factory frames to arrive we might have built half of the structure. Having said that, as our workload

CONSTRUCTION IN PROGRESS



1 SMARTPLY PROPASSIV panels fitted to the walls and roof deliver outstanding levels of airtightness; **2** Checking the Freedom Pet Pass dog door for air leaks with a smoke pencil; **3** the dog door installed in the external breather membrane; **4** roof build-up includes a breather membrane, with a 150mm ventilation zone, and 24mm WBP Plywood above; **5** this is followed by a Resitrix EPDM waterproofing roof membrane; **6** builder Mike Whitfield after others members of the team told him there was a "big leak" in one particularly difficult corner of the build.

has increased, I'm considering using more prefabricated parts so we can work on more than one at once."

The Fishleys house proved quite complex as it consists of two interlocking cubes and it required a lot of additional engineering to cantilever all the corners and the front door using dragon beams. "But it was a fun house to do with two different foundation systems," Whitfield says.

All the way through the process, Liz and Mike kept a detailed blog with pictures (www.blog.fishleys.co.uk). It started out as a way of keeping family in touch with their progress, but soon attracted a wide audience of people interested in passive houses. For example, they described how they had planted an orchard to make amends for the loss of the trees cut down to make room for the passive house.

The blog detailed the results of the airtightness tests, which initially gave a reading of 0.2 air changes per hour (ACH). Normally, passive house standards require less than 0.6, but the team had assumed 0.3 as a design target given the extensive passive house experience of those involved. A second test came back with the even better figure of 0.13 ACH, the lowest figure ever achieved by Mike Whitfield and his team, and one of the best results ever published by this magazine — especially impressive given the complex shape of the house.

Whitfield credits the collaborative nature of the project for its success and says that getting an experienced passive house builder on board early in the process is key to delivering the passive house standard as smoothly as possible.

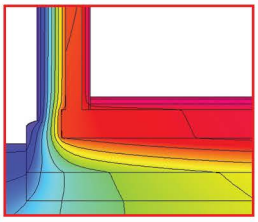
Meanwhile Caplor Energy installed 4kW of solar PV panels on the roof — these are invisible from outside because they are hidden by the roof parapet. That system has a Powerflow energy box that diverts

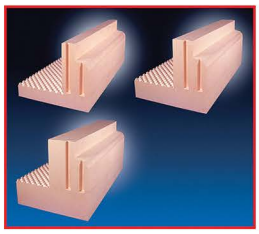


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(below) ***GEOCELL®*** *was used at the multi-storey AFG Football Arena, Switzerland*

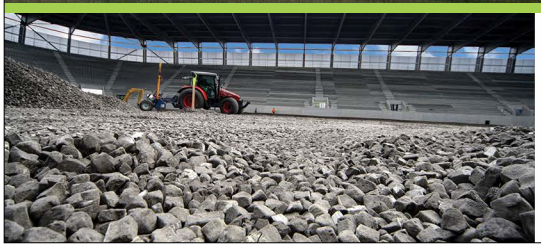
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excess electricity to heat water. Rainwater is collected from both the greenhouse and garage to be used for gardening.

The couple will now turn their sights to three new passive houses which they are hoping to build on the site of their old house. There have been no public objections to their plans and they now await the council's green light. Architype and Mike Whitfield will renew their partnership for the build. But the three new passive houses will be quite different in design to Fishleys. As they will have a close relationship with the road and be far more visible, the plan is to use a conventional pitched-roof design rather than flat roofs. Each will be put on the market with a decent-sized garden attached.

> The Fishleys house proved quite complex as it consists of two interlocking cubes.

SELECTED PROJECT DETAILS

Clients: Liz Taylor & Mike Hill
Architect: Architype
Contractor: Mike Whitfield Construction
Passive house consultancy: Architype, Elemental Solutions & Alan Clarke
M&E engineer: Alan Clarke
Structural engineer: Allan Pearce
Energy rating assessment: Energy Surveys
External insulation: Steico
Blown cellulose insulation: Warmcel, via PYC
Insulated foundation system: Isoquick
Windows & doors: Green Building Store
Airtightness tapes: Ecological Building Systems, via Green Building Store
Wind-tight membrane: SIGA
Airtight OSB board: Medite SmartPly
Plasterboard: Gyproc
Sarking board: Panelvent
I-beams: Pasquill
Flooring: Mandarin Stone
Clay-based paints: Keim
Plaster: Tadelakt, via Mike Wye & Associates
Oils & stains: OSMO
EPDM membrane: Carlisle Construction Materials
Solar PV system: Caplor Energy
Heat recovery ventilation: Paul, via Green Building Store

Read more about this project in detail

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IN DETAIL

Building type: 190sqm detached two-storey timber frame passive house

Location: Malvern, Worcestershire

Completion date: November 2016

Passive house certification: Certified

Space heating demand (PHPP): 13 kWh/(m²a)

Heat load (PHPP): 9 W/m²

Primary energy demand (PHPP): 93 kWh/(m²a)

Heat loss form factor (PHPP): 3.10

Number of occupants: 2

Overheating (PHPP): 3.9%

Airtightness (at 50 Pascals): 0.13 ACH

Energy performance certificate (EPC): B 90.

Measured energy consumption: 1,905 kWh electricity consumed during 2017. 5 x 47kg LPG gas bottles consumed for heating in same year.

Energy bills (measured or estimated): £260 spent on 5 x gas bottles in 2017 and £375 spent on electricity in same year, including VAT & standing charges. £225 received in renewable energy feed-in tariff in 2017, making for a net energy spend of £410 that year.

Thermal bridging: Thermally broken insulated raft slab and TGI balloon timber frame, thermally broken window frames with insulation over frames and Compacfoam at thresholds.

Ground floor: Thermally broken insulated raft slab to the main portion of the house: 150mm compacted base followed above by 25mm sand blinding, 250mm Isoquick EPS foundation system, 250mm reinforced concrete. U-value: 0.14 W/m²K. The ground floor study features a cantilevered timber frame detailed with dragon beams offset from the small-scale pile foundation.

Walls: 15mm Gyproc Fireline with 25mm service zone internally, followed outside by 15mm SMARTPLY PROPASSIV panels with joints taped, 350mm TGI joist fully filled with Warmcel insulation, 18mm Steico Universal board, Siga Majvest façade membrane; 50mm ventilation zone, 2x20mm hit & miss Douglas fir cladding. U-value: 0.10 W/m²K

Roof: Resitrix EPDM roof membrane externally over 24mm WBP Plywood, followed inside by 150mm ventilation zone, breather membrane over 18mm Panelvent, 400mm TGI joist roof rafters, pumped full of Warmcel insulation. On the underside, 15mm SMARTPLY PROPASSIV panels as airtight layer. Service void with 25mm battens. Gyproc Fireline plasterboard finishes to ceilings. U-value: 0.09 W/m²K

Windows & external doors: Green Building Store Progression windows & doors high quality laminated finger-jointed Spruce Thermowood windows with cork insert. Argon fill. G value 36%. Passive House certified. Overall standard whole window U-value 0.68 W/m²K.

Heating system: Worcester Bosch Greenstar 12i System (LPG) with Solar PV (Powerflow Energy recovery) to be supplied to the hot water immersion heater when there is a surplus of PV power. With Stelrad radiators.

Ventilation: Paul Novus 300 MVHR system. Passive house certified heat recovery efficiency of 94.4%.

Water: All cold-water outlets from mains, showers and bathroom cold water supply from after hot water cylinder pressure reducing valve. Conventional pipework arrangement with 22mm main pipe and 15mm to outlets. Rainwater harvesting for gardening water supply.

Shading: External solar shading blinds to selected windows.

Green materials: Tadelakt plaster, clay-based Keim Ecosil paint, cellulose insulation, Douglas fir cladding & internal linings, OSMO oil & stain, low water toilets, Oak & Travertine flooring.



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Form factor is the ratio of a building's total surface area (the walls, roof and ground floor) to its treated floor area. The smaller the form factor, the more efficient the shape of the building and the less surface area from which heat can escape. A form factor of under 3.0 is considered ideal for a passive house.

A ***thermal bridge*** is a building element that cuts across (or "bridges") the insulation layer in a building, allowing heat to escape or cold to enter.



CHESHIRE SEMI GETS

PASSIVE RETROFIT FOR £60K

Vet Chris Copeman was so meticulous about the deep retrofit of his home near the village of Frodsham that he decided to train as a passive house consultant and project manage the build himself. The result? A certified passive house created on a surprisingly low budget.

Words by Kate de Selincourt

£840
a year profit (feed-in-tariff minus energy costs)

Building: Passive house retrofit to 80sqm 1940s cavity wall semi-d
Location: Frodsham, Cheshire
Completed: 2016
Budget: £60,000
Standard: Passive house certified

With the recent, urgent call from the International Committee on Climate Change to drive net carbon emissions to zero in just 12 years, we have a lot of retrofitting to do. And as even the UK energy department (BEIS) now acknowledges, simply insulating lofts and cavities won't cut it. We must be doing whole house retrofit – but, somehow, doing it affordably. And we're not very good at that yet.

So every single example of whole-house retrofit carried out to date is a valuable part of the learning curve. A retrofit that achieves passive house on a five rather than six figure budget is an especially valuable exemplar. And if the house is identical to thousands of others up and down the country, even better.

Chris Copeman's home of ten years fits that definition perfectly. It is a modest 1940s three-bedroom ex-council semi, in rural Cheshire, and it was cold and draughty, as so many mid 20th century houses are. Chris and his partner Alex wanted to increase their living space by adding a bedroom in the attic, and most importantly, to drastically upgrade the fabric to save energy and carbon, and make the house comfortable.

Chris had already refurbished commercial premises for his veterinary practice but had found it hard to get really convincing technical advice on energy saving. "After doing research, speaking to people and going on courses, I realised that if you were going to retrofit a building it needed doing to the highest standard possible, passive house," he says.

And not one to do things by halves, Chris took a passive house consultants' course himself, so that he could be sure he was on top of every aspect.

Like most people, the couple didn't have a huge amount of money to spend on improving their house. Such a modest property would never allow Chris and Alex to recoup a massive investment, even if property prices continued to rise.

However, they were not about to compromise on quality. The couple are passionate about the urgent need for environmental action, and in particular, the need to slash carbon emissions without half-measures. And in many ways their very ordinary semi lent itself perfectly to achieving exemplary results – without exceptional outlay.

Minimal simplicity

Architect Gil Schalom, who is familiar with passive house design, was brought in by Chris and Alex to help with the initial designs. As Gil explains: "The core to the project design was minimal simplicity, in order to achieve a very high standard at minimal cost."

One of the keys to this, Gil says, was to capitalise on the simple shape and relatively good form factor (2.8) of the house. When the floor area was increased from 80 to 100 square metres by adding the loft bedroom, the Enerphit (passive house retrofit) standard target of 25kWh/m²/yr space heating demand was within reach — so Gil targeted this with his design.

Keeping the form factor simple also keeps costs down. For example, adding dorm windows to light the new attic bedroom would have increased heat loss as well as costing money and adding complication – and would also have reduced the area of the existing solar PV array. Skylights don't perform as well as vertical glazing either.

So, a single south-facing window was introduced into the gable end of the attic space – the cheapest and most energy-advantageous option. Similarly, the new porch is entirely outside the thermal envelope – as well as being re-used (it was an old conservatory).

His familiarity with PHPP meant Chris was able to take Gil Schalom's Enerphit design and, with the help of certifier Kym Mead, try out a few tweaks, such as modifying glazing and removing thermal bridges.

Eliminating the floor-level thermal bridges by introducing a course of Foamglas low thermal conductivity blocks at the base of the internal walls shaved the final kilowatts from the already low heat demand, enabling the retrofit to meet not just Enerphit, but the full passive house standard.

Building fabric

Space for insulation in the roof was limited, in order to allow for headroom in the new loft space without raising the ridge line of the roof too much. Thinner insulation was also easier to fix. So, the roof was stripped and 100mm high-performance Xtratherm PIR was installed above the rafters, covered externally with breathable membrane.

Thermafleece sheepwool insulation, meanwhile, was fitted between the 100mm rafters internally, with an intelligent,





moisture-controlling Intello airtightness membrane installed underneath this. The further 50mm of Thermafleece in the service void below this was the only insulation inside the airtightness barrier. "It was important to choose something kind here that wouldn't off-gas pollutants or irritating fibres," Chris says.

Given the relatively limited scope to improve the U-value of the roof, other elements needed to work harder to reduce the overall heat demand, Gil Schalom explains. The cavity walls already had a loose fibre fill, but external wall insulation (200mm Graphite EPS, including a Parex EHI render, adhesively fixed to avoid thermal bridging) was needed as well to achieve passive house performance.

The existing external wall cavities were sealed all the way up at the party wall junction with expanding foam, to constrain the existing insulation and reduce thermal bypass, and the roof overhang was extended at the gable to cover the external insulation — the eaves overhangs were already wide enough.

EPS was also used under the floor – the solid uninsulated concrete was dug up, and a 300mm layer of platinum EPS laid under a concrete slab with 50% ground granulated blast furnace slag. Replacing the lowest course of all the internal brickwork with Foamglas was labour intensive, but relatively straightforward. Meanwhile the external wall insulation was extended down to the footings to complete the insulation.

Airtightness work involved a mixture of broad-brush measures and more detailed, time-consuming ones. Careful sequencing was crucial. The first floor and upstairs ceiling joists were retained, so the end floorboards and plasterboard were removed to access the joist ends, which were taped onto the bare brick, before an internal parge coat of sand, lime and cement was applied right up the full height of the walls.

The Intello vapour control membrane of the roof was lapped down and also taped to the internal brickwork, ready for the plaster. Similarly, the plaster came down over the damp proof membrane (which was covered in Contega tape to ensure the plaster stuck to it) that lapped up from under the ground floor.

Sensible glazing design

Windows and doors were all replaced with triple glazed high performance timber units from Green Building Store. The windows were hung outside the masonry walls in plywood boxes, within the new external insulation layer, to reduce thermal bridging into the brickwork.

The original house actually had very little south glazing — there was just one small window in the gable end, as is standard with semis like this regardless of their orientation. The original plan was for a new large attic window, plus a second new south-facing window at ground floor level. But Chris re-thought this.

He worked out from PHPP that, because heat losses also increase with glazing area, "you do not get a massive net gain from south glazing in the UK". So, the upper window was reduced in size, and the lower one eliminated altogether.

"If you have a lot of south glazing, particularly the floor-to-ceiling kind, you can require a lot of shading – which in turn adds expense, and we wanted to keep it simple and affordable," he says.

The two smallish south windows they now have are only shaded by the reveals, but despite last summer's heat wave, they have had no problems with overheating: "All we needed to do was leave windows open at night when it was warm."

Green Building Store also helped to design a ventilation layout that fitted in unobtrusively, without any boxing in – for the most part within the eaves (the fan unit is also housed in the eaves, though accessed from the room below). Despite the fact that it is verging on the over-sized, the existing, relatively new and efficient gas boiler has been retained, and the system seems to be coping well.

The house is now very comfortable in both hot and cold weather. "The heating goes on every couple of days on average in the winter," Chris says.

Economical build

The total expenditure including bought-in labour for this retrofit was around £60,000. This includes the 'room in roof' conversion, which even in a very basic form would have required a five figure sum itself to carry out.

Chris hired local tradespeople, and project managed the work on site. However, he and Alex also did a lot of the work themselves. This added up to a considerable amount of the couple's time – obviously hard to cost, though at more than three days a week for a year, not negligible.

"It's hard to know how long a professional would have spent and how that would translate into pay, as I'm probably very slow. But on the other hand, the work that I did myself, I know I did very carefully," Chris says.

For example, the meticulous taping work was carried out by Chris and Alex working alongside joiner Dave Chalmers, based on training and advice (and a preliminary fan check) from airtightness experts Nesthaus. The care paid off, with a final airtightness of 0.27 air changes per hour achieved. Chris, along with Dave Chalmers, also installed the external wall insulation, with the rendering undertaken by their local plasterer.

This hands-on approach has advantages when you are very clear about the results you want. "I didn't like the fact that no EWI installers would use a hot wire cutter, they just wanted to cut insulation with a handsaw, which sprays polystyrene far and wide, so it seemed to make sense buying a cutter and doing it ourselves. It was a fairly straightforward job, it just requires attention to detail," Chris says.

> I realised that if you were going to retrofit a building it needed doing to the highest standard possible, passive house.

Photography: Iain Richardson



Gil Schalom explains that working this way can have other advantages: "While directly employing tradespeople can be more risky than a fixed price contract, it allows flexibility, enabling a self-builder to vary their own input as they need to. It also avoids the risk factor that contractors less experienced in passive house can sometimes load onto fixed prices."

"In this case, it paid dividends as Chris was able to spend more time on the specialist time-consuming elements such as the painstaking airtightness detail work, while delegating more standard work to the others.

"How he managed to do all this while running a vet's practice and having a young child is a little beyond me, but it seems to have really paid off.

Gil is pleased and impressed by how economically the build turned out. "For me one of the most remarkable aspects of this build is the shoe-string budget with which it was completed. The design distills the passive house requirements down to their no-frills essence, carefully controlling size and type of glazed elements and calculation of thermal bridges — an optional measure that enables you to fine-tune the amount of insulation to exactly what is needed."

For Chris, this is a really important achievement – because it shows it is possible for others to follow suit. "People say about deep retrofit — 'it's all very well setting those standards if you've got loads of money', but it's so important to try to make it affordable."

Chris is not resting on his laurels. Having

CONSTRUCTION IN PROGRESS



1 The front of the house as it was before the retrofit, with solar PV panels previously installed; **2** gutting the house prior to retrofit; **3** windows and doors were all replaced with triple glazed high performance timber units from Green Building Store; **4** the windows were hung outside the masonry walls in plywood boxes, within the new external insulation layer, to reduce thermal bridging into the brickwork; **5** walls are insulated externally with 200mm Stylite platinum EPS.



CONSTRUCTION IN PROGRESS



1 & **2** Roof build-up includes plain tiles followed inside by battens with pro clima Solitex taped wind-tightness membrane over counter battens, over Xtratherm Thin-R 100mm boards; **3** 100mm Thermafleece UltraWool between rafters; **4** airtightness taping and membrane around windows, with the original brickwork still exposed internally; **5** further taping around joist ends; **6** Paul Focus 200 heat recovery ventilation system.

completed his house (which he describes as a "warm up"), he has embarked on building a new veterinary surgery – to the passive house standard, of course. He is taking the same approach as with his own house – very hands on, project managing and directly employing local tradespeople.

"I would like to see all the technical side of things involved with passive house construction demystified," he says. "A lot of the so-called specialist jobs such as MVHR, external insulation, window installation and airtightness can be done by a good joiner, plasterer, with guidance and instructions from people like the Green Building Store or the airtightness specialists.

"I've just installed an MVHR in the new building with a joiner, who had never seen one before. He's done the whole job in four days. This makes the whole business much cheaper and more environmentally — and socially — friendly.

"The people we work with are absolutely brilliant," he says. In Chris's view, it's not really about specific passive house experience: "It's all about the attitude, about whether they are just going to do it as quickly as possible, the way they have always done it, or if they want to listen to the client and follow their priorities."

With his extremely full days – and recently, many of them spent on a building site – Chris certainly appreciates his comfortable, relaxing home. "Cycling back to our cosy home in the winter, after a hard day at work, feels like a pleasure. Although there is usually no heating on, the warmth hits you as you go in through the front door, and still feels quite magical."

SELECTED PROJECT DETAILS

Architect: Gil Schalom Design
Structural engineer: Intelligent Structural Solutions
Energy consultant: Green Building Store
Project management, passive house consultant: Chris Copeman
Electrical contractor: Kingsley Electrical Services
Airtightness consultant: Nesthaus
Airtightness tester: Richie & Richie
External wall insulation: Styrene
External insulation system: Parex UK
Sheep wool insulation: Thermafleece
Rigid roof insulation: Xtratherm
Airtightness products: Green Building Store, Ecological Building Systems
Windows & doors: Green Building Store
GGBS cement: Hanson
Gas boiler: Worcester Bosch (already installed)
MVHR: Paul, via Green Building Store
Solar PV: The Greener Group (already installed)

Read more about this project in detail

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Homeowner Chris Copeman

IN DETAIL

Building type: 80sqm 1940s cavity wall, brick-built semi-detached house

Location:
Rural location near Frodsham, Cheshire

Budget: £60,000

SPACE HEATING DEMAND
Before: 90 kWh/m²/yr
After: 16 kWh/m²/yr

Heat load (after, PHPP): 9 W/m²

Heat loss form factor (PHPP): 2.8

Overheating (PHPP): 0.4%

Primary energy demand (after, PHPP): 111 kWh/m²/yr

No of occupants: 3 (Chris, Alex and their daughter)

Measured energy consumption: 1,228kWh of electricity and 2,125kWh of gas during 2017. This increased to 2,088kWh electricity and 2,680kWh gas during 2018. Chris says this increase in electricity use was down to his partner Alex returning to work and charging their electric car more often.

Energy bills (measured): Total bill of £330 for electricity & £180 for gas during 2017; £463 for electricity & £196 for gas in for gas in 2018. These figures include standing charges. However, Chris & Alex received a feed-in tariff of approx £1,500 for solar PV generation, making for an estimated profit on energy of £840 in 2018.

Airtightness (at 50 Pascals):
0.27 air changes per hour

Thermal bridging: Inner leaf of brickwork had course of bricks removed and replaced with Foamglas Perinsul strips at level of floor insulation to connect with cavity insulation. This was repeated under retained internal brick walls. Thermal bridges calculated by Green Building Store.

FLOORS
Before: Sub-base followed above by 100mm concrete ground bearing slab (uninsulated), quarry tiles.

After: Existing sub-base followed above by sand blinding, DPM lapped up walls up to 150mm above finished floor level, 300mm platinum EPS insulation, 100mm in-situ reinforced concrete slab with 35mm PIR edge insulation (increased to 60mm next to party walls), oak floor boards reclaimed direct from another property. U-value: 0.101 W/m²K

EXTERNAL WALLS
Before: 102.5mm brick externally, followed inside by 70mm cavity with Supafill 34 silicon-treated glass mineral wool insulation, 102.5mm brick, plaster. U-value: 0.45 W/m²K
After: 200mm Stylite platinum EPS insulation and Parex Lanko EHI mineral render finish externally (adhered), 102.5mm brick, followed inside by 70mm cavity with Supafill 34, 102.5mm brick, cement/lime/sand plaster (full re-plastering). U-value: 0.113W/m²K. (EWI steps down to 180mm XPS below DPC, taken down to 30cm below ground level).

Party walls (ground & first floor): Chimney breasts removed on ground. 100mm enhanced Thermafleece sheep wool insulation between timber studs, followed inside by airtightness membrane, plasterboard. U-Value: 0.290 W/m²K

Party walls (second floor): 500mm reused loft insulation between and behind timber studs, followed inside by airtightness membrane, plasterboard. U-value: 0.075 W/m²K

ROOF
Before: Plain tiles on battens with mineral felt underneath. 300mm mineral wool insulation on the flat between roof joists and above. Plasterboard ceiling internally.
U-value: 0.15 W/m²K
After: Plain tiles reused & supplemented with secondhand tiles to match, followed inside by battens with pro clima Solitex taped wind-tightness membrane over counter battens, over Xtratherm Thin-R 100mm boards, 100mm Thermafleece UltraWool between rafters, 8mm OSB, pro clima Intello membrane taped with pro clima tapes, 50mm service void with Thermafleece UltraWool, plasterboard skimmed.
U-value: 0.12 W/m²K

WINDOWS & DOORS
Before: Timber front door. Double glazed windows and back door. U-Value: 2 W/m²K
New triple glazed windows: Green building Store Ultra Solid timber windows and doors, inward opening, mounted 100mm proud of masonry into EWI with ply surrounds. EWI lapped 50mm over frames to reduce thermal bridging. Uw = 0.75, Overall installed U-value of 0.80 W/m²K.

Heating system: Existing Worcester Bosch GreenStar 30SI condensing gas combi boiler, originally with radiators in every room, reused after with just three radiators.

VENTILATION
Before: No ventilation system. Reliant on infiltration, chimney and opening of windows for air changes.
After: Paul Focus 200 heat recovery ventilation system. Passive House Institute certified to have heat recovery rate of 89%. Spiral bound galvanised steel ductwork by Lindab.

Electricity: 4kw Sharp Photovoltaic array split east west system reinstalled. Average annual output of 3,000kW

Green materials: Secondhand mahogany conservatory purchased and restored, roofed with Welsh cedar shingles. Clay based Earthborn paint used inside, 50% GGBS cement used in floor, insulation offcuts from EWI used in conservatory floor, existing loft insulation reused in party wall. Glulam beams, re-used oak timber from local pub and local school gym, old chimney brickwork reused for paving.



UP TO

€155

per year for space & water heating
(estimate, see 'In Detail' for more)

Building: Scheme of 12 x 85 sqm social houses
Location: Dún Laoghaire, Dublin
Completed: 2018
Budget: €2.57m (ex VAT)
Standard: Nearly zero energy buildings (NZEBs)

SOCIAL SKILLS

THE A1 RAPID BUILD COUNCIL HOMES THAT ARE SUSTAINABILITY ALL-ROUNDERS

In the midst of a national housing crisis, this new development in Dún Laoghaire sets a hopeful and inspiring example: high quality, high density, rapid build social housing that needs almost no energy to heat and is within walking distance of shops, services and the seafront. No wonder it was one of the first projects to be certified to a rigorous new sustainability standard.

Words by John Hearne





Dún Laoghaire-Rathdown County Council's recent development of twelve social housing units at George's Place in Dún Laoghaire is just around the corner from the waterfront. It also lies at the intersection of a long list of diverse objectives, some of which give every appearance of being contradictory.

The houses are rapid build yet sufficiently well-built to have achieved an A1 BER. They are high-density yet each retains its own front door and avoids overlooking its neighbour. The site itself is a brownfield site and came with a list of conditions that had to be carefully negotiated before the first sod was turned. The design and build team, led by Dún Laoghaire-Rathdown's architects department, manoeuvred their way through a maze of restrictions and criteria to deliver exemplar houses in record time.

Susan Corcoran and her two sons moved into their new home in George's Place in June, just twenty-one months after the planning phase began. "We had a cottage in Dalkey that was over a hundred years old," says Corcoran. "You walked in the front door and you were in the main living areas. It was cold and it was drafty."

"What I love about our new home is that as well as being warm, there are no drafts." She also loves the fact that despite the fact that it is a relatively compact two-bedroom unit, her house feels bigger. "The windows are huge," she says, "we get brilliant light."

The best thing about her house, however, is the location. Everything is a walk away.

Bob Hannan, senior architect with Dún Laoghaire-Rathdown County Council explains that a variety of factors led to the designation of the George's Place site for social housing.

"One of the high-level themes of the Dún Laoghaire-Rathdown urban framework plan centres on connecting the town centre to the waterfront. Dún Laoghaire has that dichotomy between a main street which has underperformed and a waterfront which is buzzing with people. One of our strategies is to create as many links as possible between the two."

A second 'high-level theme' in the plan promotes the idea that increasing the residential population of the town is the best way to boost its vitality and economic performance.

With these themes guiding developments in the area since 2004, individual site strategies were drawn up to unlock their potential, while remaining within the parameters of the framework plan.

The next challenge was to find a way to deliver own-door, high-density urban dwellings in keeping with the character of the area. Bob Hannan puts it like this: "If you're going to create family housing, how are you going to do it in the most efficient way possible using precious urban land?"

The shallow, railed-front gardens so prevalent in the area offered a neat example

> If you're going to create family housing, how are you going to do it in the most efficient way possible using precious urban land?



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> Schools, healthcare, parks, shops, amenities and public transport are all close at hand.

of how to limit each house's external footprint, as did the small courtyard back garden. Splayed windows at the first floor also minimise direct overlooking of neighbours.

Surprisingly, each house even manages to get its own car-parking space, and there are what the architects describe as 'home zones' – informal play and amenity areas – which are passively overlooked by the houses themselves.

Hannan says that while the houses were still in the planning stage, the local authority received an invitation from the government to submit developments to its rapid delivery programme. George's Place became the council's response to that call.

Planning permission for the twelve houses was submitted to the local authority's internal planning process in September 2016. The project went out to tender the following February and contracts were signed in October 2017. Susan Corcoran and her family, along with all of the other tenants, moved in last June.

"We wanted to unravel the idea that rapid build is lower quality," says Hannan, explaining that the decision was taken to move large elements of the construction offsite not alone to speed things up but also to ensure higher standards.

"With a traditional build, you'd have a guy on a wet November night trying to cut

Photography: Marie-Louise Halpenny



insulation. It's dark and raining, and he's freezing. It's very hard to keep high quality in something like that.

Manufacturing in factory conditions, by contrast, ticks two boxes – speed and quality. To further facilitate offsite construction, the designs of the two types of houses deployed were kept simple. Both are two-bedroom; one narrow fronted with double aspect front and back, the other a wide-fronted shallow unit. To the same end, the design team restricted itself to a small palette of good quality, robust and easily maintained construction materials.

Though rapid build methods may be comparatively new to the construction industry, at George's Place they were

The Home Performance Index: measuring sustainability in Irish housing

Words by Pat Barry, Irish Green Building Council CEO

Why do we need new a sustainability rating system with the advent, across Europe, of the new nearly zero energy building (NZEB) standard? NZEB for dwellings requires an improvement from an A3 to an A2 BER rating. This represents an overall carbon saving of about 300kg per annum for a sensibly-sized 80 square metre house, or half a tonne for a bigger three-bed home. This is a start but needs to be seen in the context of the total carbon emissions associated with how we design and where we place our homes.

Ireland's per capita carbon emissions are way out of line with the rest of Europe at nearly 13 tonnes per capita versus just over eight tonnes for the European average. It's not just down to seven million belching cattle, but to the massive resource consumption associated with our legacy of laissez faire planning. The Home Performance Index sets out to capture and reduce these impacts for new home development.

What does it measure?

The Home Performance Index was designed to be easy to apply and fully integrated with Irish building regulations. It is divided into five categories: environment, health and wellbeing, economic, quality assurance and sustainable location, each containing a set of indicators.

It starts with the site. Inefficient land use for home construction leads directly to habitat degradation and fragmentation, pollution, and soil sealing, which increases the risk of flooding and negates the ability of soil to sequester carbon. A typical one-off home on a quarter hectare is a missed opportunity to sequester, through forestry, 800kg of carbon per annum, or improve to biodiversity.

The HPI measures a site's accessibility to a range of transport options: walking, cycling, public transport and carsharing. We can't fix bad sites with electrical vehicles, but we'll make much faster progress if we only build homes where citizens can live free of the need to own cars altogether.

Mandatory requirements are also set in the most important areas, such as water efficiency, ventilation, thermal bridging, and enhanced airtightness. For example, we set a maximum air infiltration level of 3 m^3hr/sqm/50pa, as opposed to 7 in the current building regulations. But we also insist that a properly designed and commissioned ventilation system is installed too. The HPI also sets a maximum annual heat demand, encouraging builders to provide the most efficient building fabric-first, rather than achieving a higher rating through renewables.

Water efficiency is now a key part of achieving NZEB with data from SEAI showing that hot water accounts for over 70% of regulated energy in NZEB apartments. The HPI links into existing databases and calculators for water efficiency provided by the European Water Label to help designers design for efficiency.

Embodied carbon

The HPI encourages compact home design and measurement of the embodied carbon of a build. An NZEB home has operational regulated emissions of about 8kg per square metre per annum, but we lack good figures for Ireland for embodied carbon. Figures from other countries suggest between 600kg and 900kg per square metre of floor area. So excess home size can send carbon emissions through the roof.

Figures for 2016 showed that the average new build detached house in Ireland had an average floor area of a whopping 241 square meters, an increase of 60% since 2000, thus wiping out the 60% improvement in energy efficiency in the same period. Common sense could achieve greater carbon savings than technology.

To support the HPI, the IGBC is developing the infrastructure for measuring the embodied carbon of buildings, establishing an environmental product declaration programme (www.EPDIreland.org) to provide the data for calculation. This has been very successful, Irish manufacturers have reacted quickly, and we have already verified 16 EPDs covering over 40 products for Quinn Building Products, Kore, Ecocem, Medite SmartPly, and Munster Joinery. We have also provided training in life cycle assessment and embodied carbon to seed knowledge into the industry.

This year will now see many large developments certified by the HPI including the Cherrywood development of 1,269 homes in south Dublin by Hines, plus at least 12 social housing schemes. The HPI is also now specified as standard in tenders by Dublin City Council.

Green mortgages

A key purpose of the HPI is to define for banks, investors, pension funds, developers and government a robust way of defining what type of development can be considered sustainable, and therefore what should be financed.

IGBC has been working with the World GBC and the European Mortgage Federation on the development of energy efficient mortgages, which are now being piloted by 40 banks across Europe. IGBC is also starting a new initiative with 16 other international partners later this year, which aims to further develop green mortgage programmes and expand them beyond just simplistic energy efficiency. Denmark Technical University will carry out detailed research on the total monthly costs of homes, providing real data that support banks in offering discounted interests on mortgages for greener homes, based on their lower default risk.

For more information on HPI certification, and the full technical manual, see **www.homeperformanceindex.ie**. More on the Irish Green Building Council at **www.igbc.ie**.

delivered by Sisk Living, a new division of John Sisk & Son – one the oldest and most trusted builders in Ireland.

John Sisk & Son CEO Stephen Bowcott spoke to Passive House Plus about the company's motivation: "For generations Sisk have been at the centre of house building in Ireland and particularly at times of social need. With the onset of the housing crisis and in support of Rebuilding Ireland, we set up Sisk Living as a specialist residential building division with a clear vision: to become the premier house building contractor in Ireland in terms of size, speed and quality with the lowest possible cost to the end user. George's Place was one of our earliest projects and we are very proud of our achievement in delivering it."

According to Sisk Living director of housing, Norman Higgins, the project was a perfect fit for them. "With near zero energy building (NZEB) soon becoming mandatory for all new housing stock, we wanted to test ourselves to deliver this standard as early as possible. George's Place was a very attractive proposition for us, not only because of the NZEB factor, but also because it was an extremely fast build on a technically challenging city centre site which allowed us to bring our expertise to bear."

It may sound contradictory but while this was a busy city centre location, it was also, a quiet and thriving residential area. Poor relationships can develop quite quickly between a very busy contractor and neighbours in a location such as this. Managing this aspect of construction was about the smaller things like





> Increasing the residential population of the town is the best way to boost its vitality.

CONSTRUCTION IN PROGRESS



1 Two courses of Quinn Lite AAC blocks used in subfloors at perimeters and party walls to reduce thermal bridges; **2** the ground floor also features 150mm XT Xtratherm insulation and a radon control membrane; **3** panels being lifted into place for the timber frame structure; **4**, **5** & **6** the Kingspan Century Ultima wall system takes only between three and four days to erect once it arrives onsite, and delivers high levels of thermal performance and airtightness; **7** Airtight Pro SCL membrane on the internal side of ceiling; **8** Kingspan PIR insulation to the inside of the roof construction; **9** windows & doors in place, and work begins on fitting the external brickwork over a Protect TF200 Thermo breather membrane.

keeping neighbours informed of what was happening and reacting to any query promptly and respectfully.

One significant sustainability initiative that Sisk Living brought to the project was to register it with the Irish Green Building Council's (IGBC), Home Performance Index (HPI). Sisk Living then made continuous submissions to HPI through construction and last May, George's Place was awarded a silver certification under the exacting scheme. The HPI label was developed by the IGBC to encourage excellence in the development of new homes. In addition to the sustainability of a dwelling, HPI assesses its impacts on wellbeing and the costs associated with living in these homes. Drilling down through the HPI documentation, you uncover some interesting results. For example: George's Place received the highest ever score for 'walkability'. Schools, healthcare, parks, shops, amenities and public transport are all close at hand, reducing car dependency and boosting the health and financial wellbeing of those who live there.

Dún Laoghaire-Rathdown County Council architects appointed A2 Architects as 'enabling architects' to undertake the detailed tender package after planning had been approved and to manage the project during the construction phase.

Peter Carroll of A2 says that the site itself was very challenging.

"You wouldn't think that it would lend itself to rapid delivery construction," he says. "We had difficulties with Japanese knotweed, there were more than a dozen boundary conditions, and we had to deal with existing buildings onsite that had to be remediated to hold onto their integrity."

The build team also had to take into account the fact that they were surrounded by busy roads, and that the site lay at the centre of a thriving residential area.

"We had to ensure that our tender drawings and detailed design were as accurate as possible, and as specific as possible. This was a government contract that didn't allow any slack."

Everything, from the pressings of the sills to the ridge details, railings and hard landscaping were closely specified by A2 in collaboration with Dún Laoghaire-Rathdown architects well in advance. Having said that, Carroll notes that a number of tolerances were built into the tender to allow participating parties to suggest rapid delivery systems. Sisk Living selected the Kingspan Century Homes rapid build



> What I love about our new home is that as well as being warm, there are no drafts.



timber frame system, which takes between three and four days to erect once it arrives onsite.

It was originally envisaged that the houses would be certified passive, and while they don't quite meet certification thresholds, passive principles are embedded in the design.

As Bob Hannan asserts, Dún Laoghaire-Rathdown is one of the most progressive local authorities in the country when it comes to energy standards.

"It may not be certified but it does have fabric-first principles – very high levels of insulation and airtightness, combined with mechanical heat recovery ventilation. The development is an exemplar in terms of pushing high performance building to its limit, and that is driven by the council itself, and our department in particular."

For the record, air permeability tests report values of between 1.24 and 3.2 $m^3/hr/m^2$ at 50 Pa, with all bar two units clocking scores of under 2.0 – while U-values are within passive house ranges, as are thermal bridging details. The units also blitzes Ireland's new nearly zero energy building standard (NZEB), which only came into force at the start of this year.

Peter Carroll says that during the tendering process, the passive house strategy was retained in order to attract like-minded contractors who would not be intimated by exacting standards. And that explains how the development secured such a high score in the Irish Green Building Council's HPI scheme.

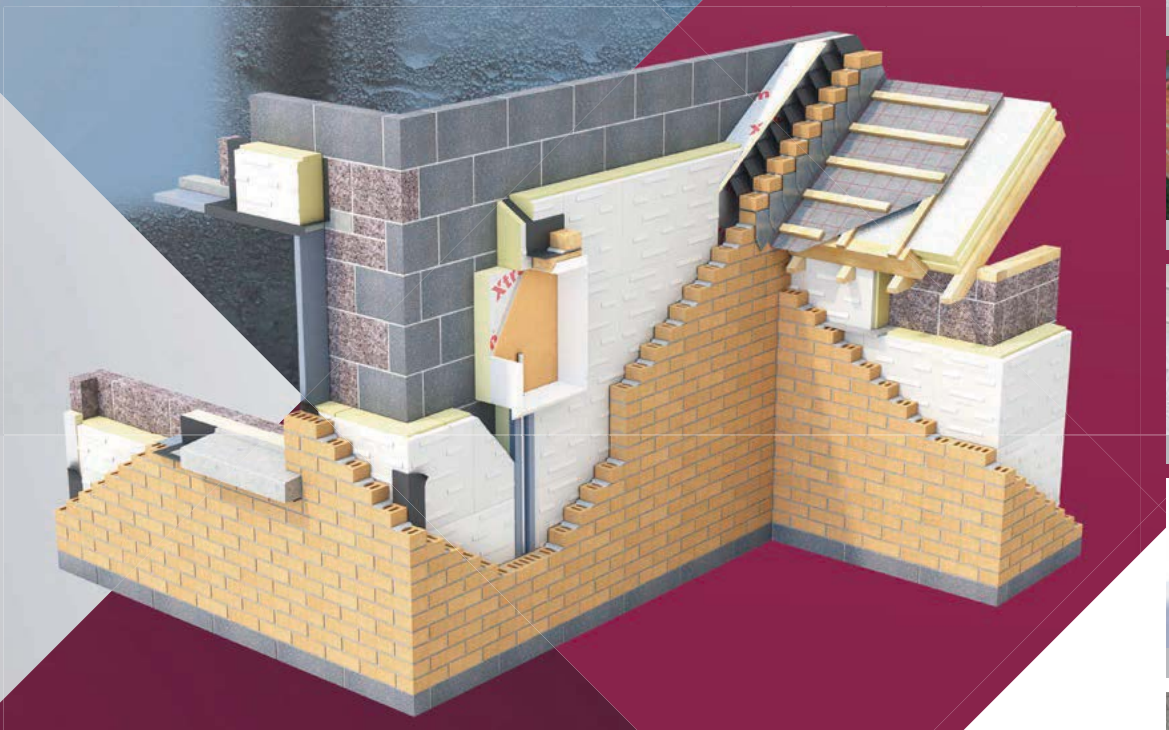
The fact that these houses were built for €249,000 (incl. VAT) each also gives the lie to the idea that a fabric-first, low energy build is an expensive build. And because each house carries an A1 BER, running costs for the tenants should not exceed €200 per year.

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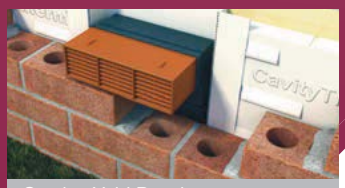
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Susan Corcoran points out that because we've had such a mild winter – so far at least – her house has not been seriously tested by the elements. Indoor air temperature over the last eight months has remained steady, warm and comfortable. She likes the fact that she has constant hot water, that yearly maintenance of the system is built into her rent and that the controls for the Nilan Compact P combined heat pump and ventilation system are so easy to use.

"It's a touch screen with an up and a down arrow," she says. "Couldn't be easier."

SELECTED PROJECT DETAILS

Design architect: Dún Laoghaire-Rathdown County Council architects department
Enabling architect: A2 Architects
Contractor's architect: O'Mahony Pike
Project management: A2 Architects
Main contractor: Sisk Living
Timber frame: Kingspan Century
Client's M&E engineer: Delap & Waller
Contractor's M&E engineer: Johnson Reid & Associates
Client's civil / structural engineer: Punch Consulting
Contractor's civil / structural engineer: DBFL
Contractor's energy consultant: Johnson Reid & Associates
Electrical subcontractor: Drysdale Mechanical & Electrical Services
Mechanical subcontractor: Gaffney Mechanical
Client's quantity surveyor: Nolan Construction Consultants
Airtightness tester: Energy First Services
Windows: Velfac, via Novus Windows
Solar PV: PV Green
Insulation contractor: Baker & Co
Airtightness products: Dupont Tyvek / Airtight Pro / Ecological Building Systems
Zinc roofing: Copeland Coppersmiths Ltd
GGBS: Ecocem
Flooring: Forbo
Wall board: Gyproc
Floor insulation: Xtratherm
Mineral wool insulation: Knauf
Fire breaks: Rockwool
Thermal blocks: Quinn Building Products
Radon barrier: Radon Ireland
Breather membrane: Protect
Flooring particleboard: Norbord
Zinc roof: Rheinzink
Attenuation tank: Microstrain
Bricks: Ibstock
Render & white mortars: Kilsaran

Read more about this project in detail





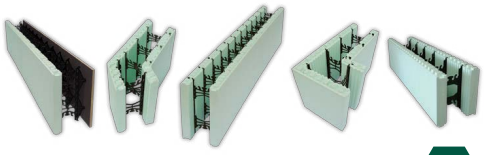


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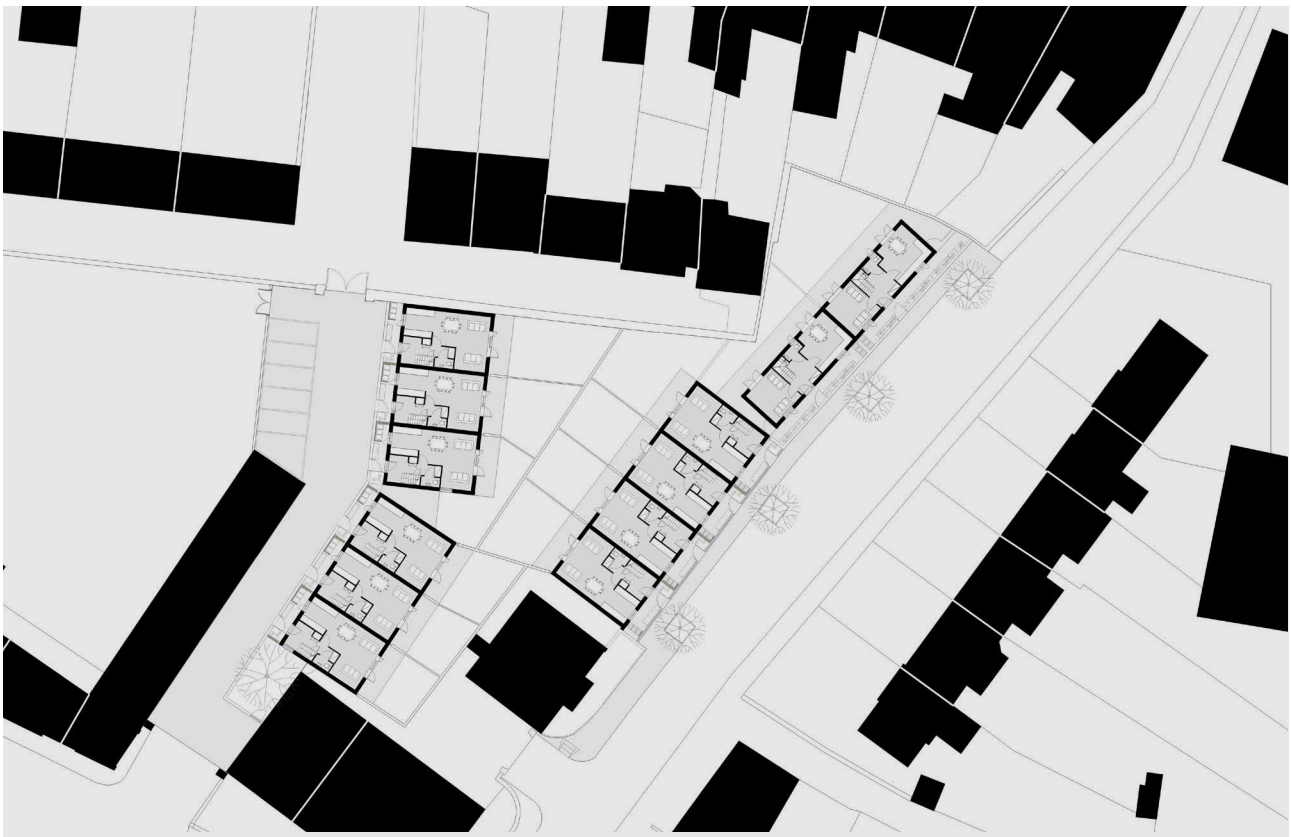
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IN DETAIL

Building type: 12 x 85 square metre timber frame town houses

Location: Dún Laoghaire, Co Dublin

Completion date: May 2018

Budget: €2.57m + VAT @13.5%

Passive house certification:
Not assessed in PHPP

Primary energy demand (DEAP):
18 to 23 kWh/m²/yr (range of all 12 units)

Heat loss form factor (DEAP): 2.77 to 2.90

Energy performance coefficient (EPC):
0.123 to 0.137 (range of all 12 units)

Carbon performance coefficient (CPC):
0.117 to 0.132 (range of all 12 units)

BER: A1 rated (all units, as per DEAP primary energy demand above)

Environmental assessment method: IGBC Home Performance Index Silver Certified

Measured energy consumption: N/A

Airtightness (at 50Pa): 1.24 to 3.2 m³/hr/m² (range of all 12 units; note all but two units scored under 2.0 m³/hr/m²)

Thermal bridging: Kingspan Ultima wall system designed to minimise thermal bridging. Two courses of Quinn Lite AAC blocks used in subfloors at perimeters and party walls. Y-values of between 0.0119 and 0.0307.

Energy bills (estimated): €15.36 annually for space heating & €125.45 for hot water for dwelling type one; €30.36 for space heating & €124.66 for hot water for dwelling type two. Figures calculated based on DEAP energy consumption projections for HPI assessment.

Ground floor: 225mm insitu concrete floor slab followed below by 1000-gauge polythene separating layer, 150mm XT Xtratherm insulation, radon control membrane, 50mm sand binding, compacted hardcore. U-value: 0.12 W/m²K

Walls: Outer leaf – ten units with Ivanhoe Cream Dark End brick, two units with 20mm Kilsaran GP Render externally followed inside by 100mm blockwork external leaf – 50mm cavity, Kingspan Ultima 185 timber frame consisting of breather membrane, 9mm OSB, 89mm studs with PIR insulation, airtightness/vapour control membrane, 50mm PIR insulation, 35mm timber battens to create service cavity, 12.5mm plasterboard and skim finish.
U-value: 0.12 W/m²K

Roof: Zinc roof externally, followed beneath by 7mm double standing roof seam, on vapour-permeable separating layer/ underlay, on 18/22mm marine ply deck fixed to timber roof joists. Min 50mm proprietary eaves ventilation try. Roof insulated at ceiling level with 150mm Knauf Earthwool insulation above and between joists, followed beneath by airtightness/vapour control membrane, 30mm Kingspan PIR insulation, 30mm service void and 12.5mm plasterboard/skim finish to all ceilings.
U-value: 0.12 W/m²K

Windows: Velfac V200 Energy triple glazed, argon-filled timber aluclad windows.
Overall U-value: 0.82 W/m²K

Heating & ventilation: Nilan Compact P combined heat recovery ventilation / exhaust air heat pump system providing balanced whole-house heat recovery along with all space heating & domestic hot water requirements.

Electricity: 4 x 290W solar photovoltaic panels per dwelling.

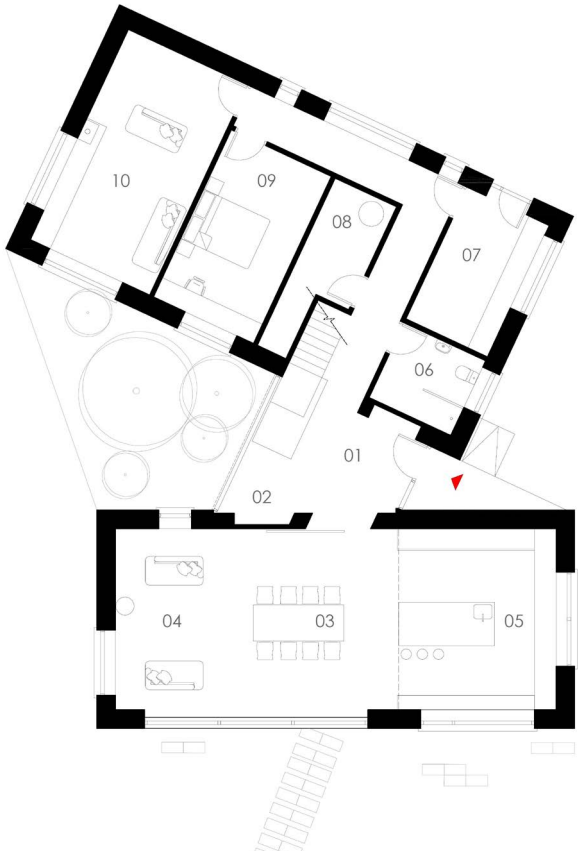
Green materials: Many specified construction products had high sustainability ratings quantified in Environmental Product Declarations (EPDs) including Forbo marmoleum flooring, Ecocem GGBS, Dulux Vinyl Matt paint & Gyproc wallboard.



FIELD OF DREAMS

Designed in a traditional farmhouse cluster on a greenfield site amid the hedgerows of rural Cork, this new passive home by the River Sullane pays deep attention not only to energy efficiency but also to natural light, elegant design and preserving the ecology of its sensitive setting.

Words by John Cradden

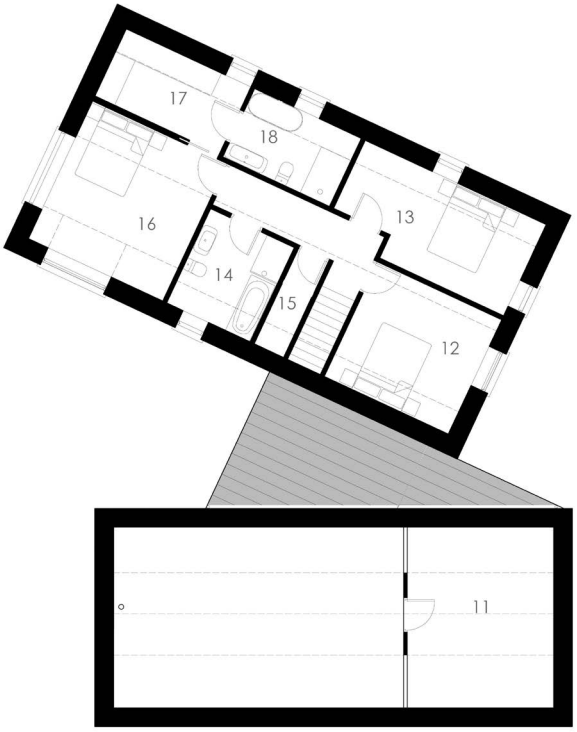


GROUND FLOOR PLAN

€91 per year space heating (estimate, see 'In Detail' for more)

Building: 232 sqm detached timber frame house
Location: Cork, Ireland
Completed: March 2018
Standard: Uncertified passive house, NZEB (Ireland)





FIRST FLOOR PLAN

> I was struck by the wild landscape of ferns, grasses, heather and briars and sound of the river.



They say Macroom is the town that "never reared a fool", and if the quality of a new passive house located near the Cork town is any evidence, it may just be true.

As well as being locals to the area, it probably helps that homeowners Oliver Long and Aisling Buckley work in the construction industry — he as a quantity surveyor and she as a civil engineer — and between themselves and architect Neil Kane, they were able to pull together a strong line-up of professionals to make their dream NZEB-beating new build a reality.

Built on a large site 3km away from Macroom town centre and where the River Sullane flanks its southern border near Linnamilla Bridge, this attractive cluster of farmhouse-style buildings nestles nicely within the wall of mature trees that surrounds the site.

If you're familiar with Cork County Council's design guidelines for rural homes, you can see straightaway that this home aligns nicely in terms of where the individual buildings sit on the site, as well as its simplicity of form and absence of frills.

But there was also a great deal of thought about the dwelling's relationship to the landscape. Amid a fairly extensive design process, Kane produced a large (1:200) model that included the whole site, and which allowed all involved to see clearly the advantages and disadvantages of various locations.

"In planning terms this was always going to be a hard sell given the natural beauty of the site and proximity to the river," says Kane. "So, when we met with the local area planner the design was well developed and we prepared 3D visualisations. The planner's comment was 'Wow…I wish this was my house!'".

The garage, for instance, provides a barrier to the road for privacy and noise. "It was the logical location as it doesn't affect views from the house," says Kane.

According to Kane, the initial design began with the two main buildings parallel to each other (the smaller of the two contains the open-plan kitchen and living area), but a decision was taken to angle the bigger two-storey bedroom block to allow more solar gain to the north corner, and to enable better internal views throughout the



> The building materials were chosen with an eye to low-maintenance, robustness and longevity.

house and out to the landscape.

This had the effect of turning the linking block (and front entrance) between the two houses into a wedge shape and creating what is probably its strongest architectural feature."It's a bit of a design trick where the entrances are so important," says Kane, describing the narrow and low portal that opens up to a wider and higher space.

"Sometimes you need to get the maximum impact; it has less impact if you have a very high canopy above you when you walk into a space...[But] when you come into this space, it's a little higher as you walk inside the lobby and then you have this large window looking out and the stairs to the right of that, and you're looking straight out into the landscape."

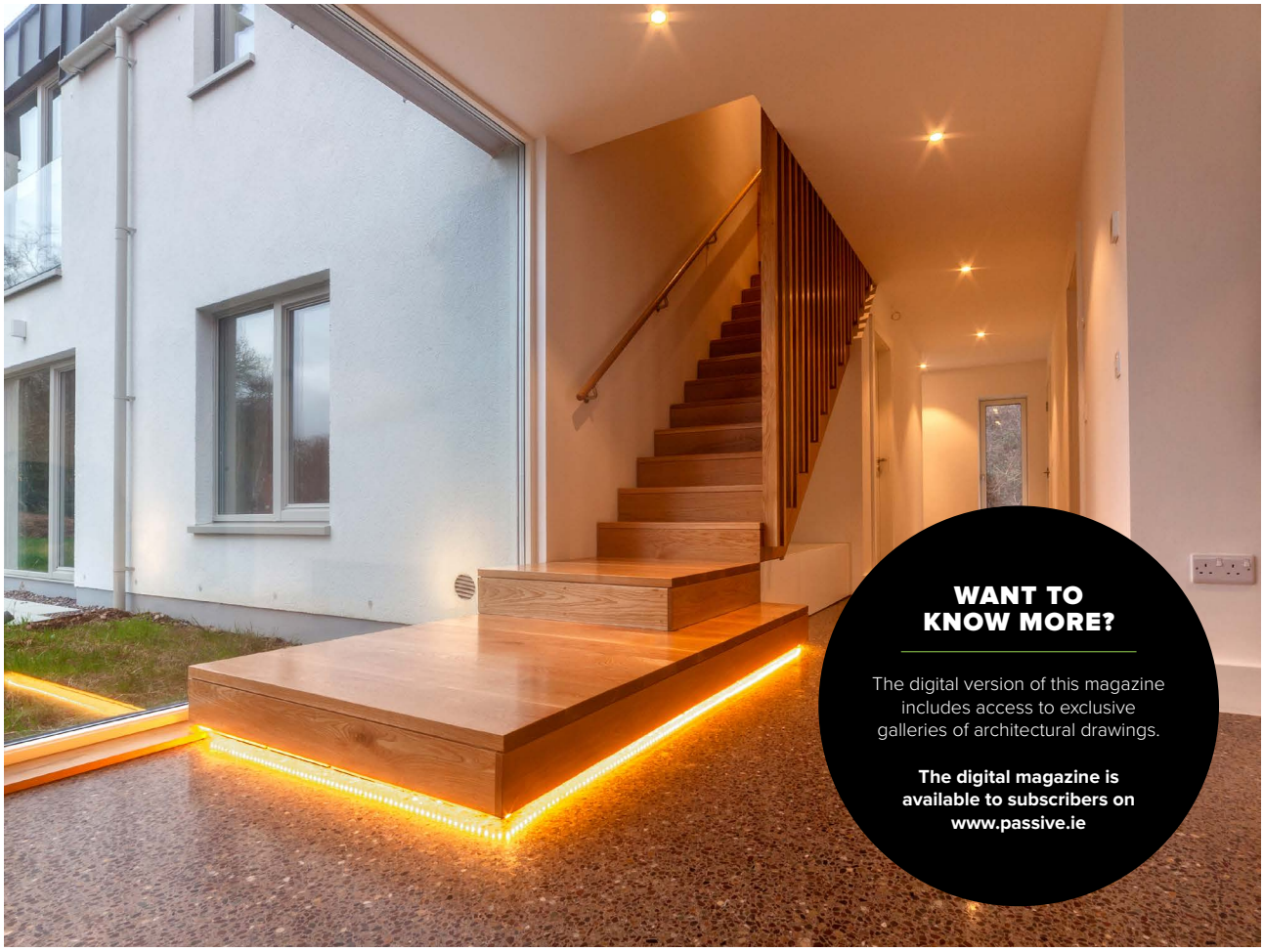
The large window looks out to the west of the site, which contains the thickest area of hedgerows and trees.

When the couple bought the site in 2014, it was somewhat overgrown and left to the wilderness, but they were anxious not to disturb its natural quality too much.

"When I first visited the site I was struck by the wild landscape of ferns, grasses, heather and briars and sound of the river as it sped-up towards Linnamilla Bridge," says Kane.

"We avoided the common approach of cutting down the roadside hedges by meeting the local roads engineer on site





WANT TO KNOW MORE?

The digital version of this magazine includes access to exclusive galleries of architectural drawings.

The digital magazine is available to subscribers on www.passive.ie

Photography: Dermot Fitzgerald Photography

> The couple love the large glazing for the light and views of nature.

and discussing sightlines and, through this discussion, the mature ash tree at the entrance was retained."

This strong conservation mindset extended to moving, rather than chopping down, a relatively young blackthorn tree that sat in the centre of the site, and which now thrives in a new location to the south of the house.

"The house is surrounded by nature and we are lucky enough to see lots of native species all around us here. We also intend to enhance the natural environment by planting native trees," says homeowner Oliver Long.

The couple's interest in conservation dovetailed nicely with an open-mindedness about building to the passive house standard, as per Kane's recommendation.

"We were aware of and interested in pursuing passive house standards, but we did not know if they were achievable without compromising on design, floor area and/or budget," says Long. "As we set out on the project, we were willing to investigate this."

The buildings are all timber-framed (which was handy given that suppliers Cygnum are based just 5km away) with a concrete block outer leaf and silicate render finish.

The building materials were chosen with an eye to low-maintenance, robustness and longevity — an environmental approach in itself, says Kane, but the green credentials are also bolstered by the use of cellulose (recycled newspaper) insulation, natural slates, and local field stone for the entrance walls.

The PHPP (passive house design software) calculations were done with site-specific climate data, and while the dwelling is not

CONSTRUCTION IN PROGRESS



1 Site entrance view in April 2016; **2** the ground floor features a course of Quinn Lite B7 aircrete blocks to perimeter; **3** erection of the Cygnum timber frame structure almost complete; **4** Gerband SD2 Control airtight vapour barrier fitted to inner side of wall; **5** ductwork for the BEAM Axco heat recovery ventilation system; **6** palette of materials and finishes used on the project; **7** oak stair tread with the polished concrete floor underneath; **8** natural slates being installed on the roof; **9** the house nearing completion.

yet passive house certified, the clients plan to submit for certification this year. It also meets Ireland's new nearly zero energy building (NZEB) standard (see 'In detail').

Heating, meanwhile, is courtesy of an air-to-water heat pump and underfloor heating on the ground floor, plus some radiators upstairs, which altogether provide a heating load probably well above what the house needs. Unusually, as builder Rodney Cronin of Vinro Construction explains, the heat pump is controlled via individual room stats, for a couple of reasons – there's the fact the house isn't as open plan as many passive houses; and that it's divided into two linked buildings. "The rear building is being shaded by the front building – so wouldn't get anywhere near as much solar gain as the front building," says Cronin. "The stats turn off the rooms that reach temperature sooner and maintain a heat supply to the Northern rooms – in order to get the house to an equal level."

Long admits that the house's two stoves very rarely get lit, and the couple may need to invest in blinds for the kitchen and living room area, as the south-facing rooms tend to get hot in the summer.

Kane says that "the mature trees do help with shading but that the addition of louvres or a brise soleil of some sort might be advised in the future if we keep having summers like 2018." But he adds that good cross-ventilation strategy was part of the design detail, which enables hot air to escape quickly through opened windows.

Long reports that they managed to keep relatively close to the budget thanks to "a good set of contract documents" although Kane adds that some details from the tender design had to be omitted, including the brise soleil to the south facade.

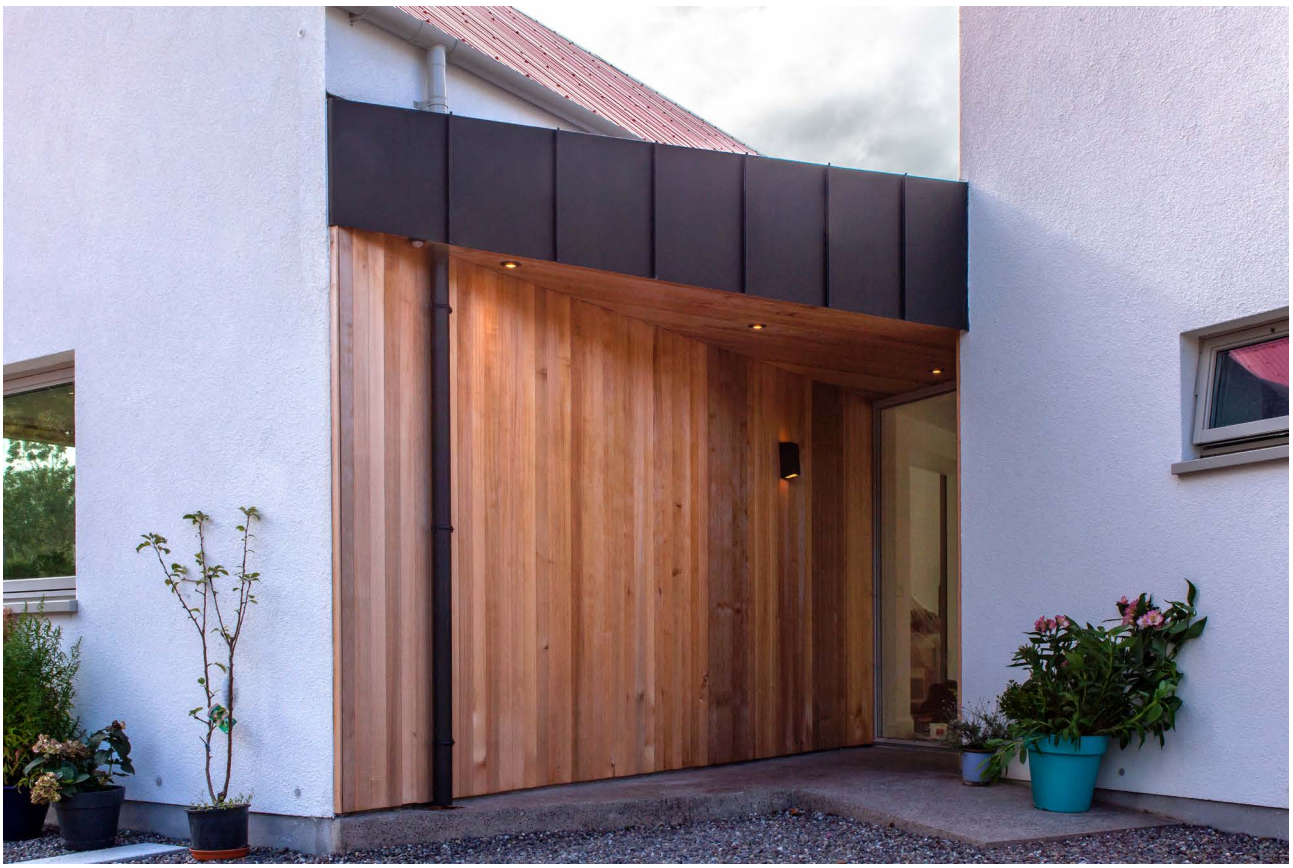
"Generally, as an architect some of our good ideas are dropped because of budget, but thankfully some very nice items were retained on this project, including the oak coat hanger detail that I designed for the entrance lobby and made by Ruairi Brennan, a local joiner who also made the stairs."







> The consistency of temperature in the winter time is lovely.





above Happy homeowners Oliver Long, Aisling Buckley & family with architect Neil Kane

Long and Kane are full of praise for the construction team, including main contractor Rodney Cronin, passive house consultant Evan Finegan, building services consultant Mark Buckley and landscape architect Cathal O'Meara.

However, Kane sounds a general note of warning about the difficulty of finding skilled tradespeople for passive builds now. "Due to increase in construction activity there is a shortage of skilled trades people now coupled with a shortage of construction apprentices coming through," he says. A skills shortage often results in delays and higher costs with some specialist elements of the works on site."

Having lived in the for about a year now, the couple love the large glazing for the light and views of nature all around them that it provides. "It feels different to any house the we have lived in previously, or any building we have been in for that matter," says Long. "The consistency of temperature in the winter time is lovely, especially the warm floors and lack of drafts. We are still getting used to the comfort that it provides."

"Our electricity bill has hardly changed from the house that we were renting previously, even though it now also includes all heating costs."

SELECTED PROJECT DETAILS

Clients: Oliver Long & Aisling Buckley
Architect, design & assigned certifier: Kane Architects
Civil / structural engineer & PSDP: DJF Engineering Services Ltd
Mechanical & electrical engineer: MBA Consulting Engineers
Landscape architect: Cathal O'Meara Landscape Architects
Energy consultant: Evan Finegan
Main contractor: Vinro Construction
Timber frame: Cygnum Timber Frame
Airtightness test: Clean Energy Ireland
Windows & doors: NorDan Vinduer
Heating system: Pipelife Ireland
Stoves: Macroom Stoves
Natural slate: Lagan Building Solutions
External silicate render: Sto
Cedar cladding: Cedarlan
Rainwater goods: Retlaw Guttering
Concrete polishing: Cutsue
Roof sheeting: Tegral
Tiles & timber flooring: Delforno
Internal doors: Deanta Doors
External finishes: Kilsaran International
Joinery: Brennans Carpentry & Joinery
Zinc roofing: Wychbro Copper Smiths
Kitchen: Callan Kitchens

Read more about this project in detail



IN DETAIL

Building type: Detached 232 sqm timber frame house with concrete block outer leaf.

Location:
Linnamilla Bridge, Macroom, Co Cork

Completion date: March 2018

Passive house certification: Not certified

Space heating demand (PHPP): 14.3 kWh/m^2/yr (using site specific climate data).

Heat load (PHPP): 10.2 W/m^2

Primary energy demand (DEAP): 39.52 kWh/m^2/yr (does not include plug loads)

Heat loss form factor (PHPP): 3.5

Number of occupants: 4

Overheating (PHPP): 0.4% of a typical year above 25C (site specific climate data)

Energy performance coefficient (EPC): 0.261 (NZEB: 0.302 or less)

Carbon performance coefficient (CPC): 0.246 (NZEB: 0.305 or less)

BER: A2 (39.52 kWh/m^2/yr)

Airtightness: 0.56 ACH at 50Pa

Thermal bridging (architect's note): We included a Y-value of 0.08 in DEAP assessment, as all details are in accordance with Acceptable Construction Details (ACDs) for Part L 2011. We have bettered this value but without thermal modelling on each detail this default is used. There are also standard PSI values for standard details available from Part L, but the construction is not a standard timber frame construction and these PSI values may not be applicable, so we could not calculate a custom Y-value in this manner. We followed best practice for ACDs under Part L and/or followed passive house best practice detailing.

Estimated space heating costs: €91 per year – based on PHPP calculated space heating demand, assuming 100% of space heating via heat pump, at an SPF of 400%, with a 50/50 split between day rate and night rate electricity, based on Energia Cheapest Electricity rate.

Measured energy consumption: Estimate of 9,175 kWh of electricity (5,354kWh day rate & 3,821kWh night rate) used in first year. Extrapolated from actual use for first 327 days, 24 March 2018 to 19 Feb 2019. Covers all heating & electricity, bar any very occasional use of stoves.

Energy bills (measured or estimated): The figures above, based on Energia Cheapest Electricity rate (a day rate of 14.91C per kWh and night rate of 6.3c per kWh yields an annual bill of €798 + €273 = €1,071 - excluding standing charges & PSO levy.

Ground floor: Standard strip foundation; 75mm concrete screed with bronze polished finish followed below by 1000-gauge polythene, 180mm Kingspan Thermafloor TF70 rigid PIR insulation, 150mm reinforced concrete slab, well-compacted hardcore and sand binding. Quinn Lite B7 aircrete blocks & 100mm Kingspan TF70 PIR insulation to perimeter. U-value: 0.13 W/m^2K

Walls: Sto Silco silicate render system externally, followed inside by sand & cement, render, 100mm standard blockwork, 50mm ventilated cavity, Protect TF200 breather membrane, 9mm OSB3 board, 140mm timber stud + 51mm thermal break + 89mm timber stud with 280mm factory-fitted cellulose insulation, Gerband SD2 Control airtight vapour barrier, 9mm OSB3, 50mm service cavity insulated with Isover G3 Touch high performance mineral wool, 12.5mm plasterboard with skim finish. U-value: 0.13 W/m^2K

Roof: Tegral Fineline 19mm sinusoidal profile metal sheeting / Rozadais natural slate, followed underneath by 50x50mm battens, Protect TF200 breather membrane (& sealing tapes), 250mm PIR insulation, Gerband SD2 Control airtight vapour control layer, 50x50mm battens, 12.5mm plasterboard with skim finish. U-Value: 0.14 W/m^2K

Windows: Triple glazed Nordan NTech Villa aluminium clad thermally broken timber windows. NTech Passive with 105mm frame, laminated low energy glass with argon filling & warm edge spacers. U-value: 0.70 W/m^2K

Roof windows: Velux GGU 0062 thermally broken triple glazed roof windows. U-value: 0.81 W/m^2K

Heating system: Hitachi Yutaki-M 11kW air-to-water heat pump COP 5.0 (7C-30/35C). Underfloor heating to ground floor. Radiators upstairs. 60L Buffer. 300L hot water cylinder.

Ventilation: BEAM Axco heat recovery ventilation system. 92% heat recovery efficiency.

Electricity: 6M2 Phono Solar Monocrystalline 1KW PV array

Green materials: Locally sourced timber frame, Fermacell dry lining board, natural slate, cellulose insulation, all timber for frame and joinery from PEFC certified sources, 50% GGBS cement, local field stone for entrance walls.



The PH+ guide to STRUCTURAL TIMBER

Fuelled by the need to build quickly and to increasingly tight sustainability standards, the market for timber frame and mass timber construction is growing rapidly. This detailed guide covers many of the main established and emerging techniques, and looks at key issues to address if you're considering a timber-based build.

Words by John Cradden & Jeff Colley

Timber frame construction has traditionally proven a popular choice for people interested in sustainable building for a variety of reasons, not least because of its ability to reduce environmental impacts compared with traditional concrete-based construction: less embodied energy, a lighter carbon footprint and, in its prefabricated forms, arguably less waste on site.

Timber frame has long been the dominant build method in Scotland and has risen rapidly in the UK and Ireland due to the need to build rapidly while meeting tightening building standards. The market share of timber frame in Ireland grew from very little to in the region of 30% of new home builds during the Celtic Tiger years, and although it was marketed as boasting superior energy efficiency compared to masonry, in truth its rise – at a time when the construction industry was paying little more than a cursory regard to energy – owed more to the ability to build quickly and overcome onsite labour shortages.

While arguments abound about whether timber frame is superior or inferior to other build methods in terms of energy efficiency, the reality is that it's possible to build well or badly using any build method. Whatever the approach, the key is quality control and attention to detail. It's true that many of the exemplary low energy buildings published in this magazine and its predecessor Construct Ireland over the last sixteen years are timber framed, and that, especially in the infancy of low energy building, concrete-based approaches – with a heavy reliance on onsite skills to deliver airtightness and correct installation of insulation – often weren't at the races.

But these days the playing field has levelled out as the industry has learned how to adapt cavity wall construction towards low energy requirements or switch to alternative concrete-based approaches – ranging from insulating concrete formwork, with its inherent airtightness and continuity of insulation, to externally insulated single leaf construction – with the ultimate choice between systems depending more on clients' individual preferences and circumstances, including budgets.

But timber frame is arguably the most 'tried and tested' method of construction in the world, with over 70% of the population in the developed world living in timber frame housing, albeit of wildly divergent quality.

In Ireland and most of the UK, masonry remains the predominant choice, but the superior speed of off-site, prefabricated timber frame construction allowed it to grow market share here to up to 35% during the boom years.

In Britain, timber frame manufacturing has doubled since the turn of the century, with industry turnover up 10% from 2007. Experts predict that the method will continue to grow in popularity in England and Wales, catching up on the 75% market share it currently enjoys in Scotland.



1 The Horyuji Temple in Japan, the world's oldest timber building, is 1,300 years old; **2** the 18 storey Mjøsa Tower, currently under construction, is on course to be the world's tallest timber building.

What is timber frame?

A timber-framed house is a house where the primary load-bearing structure is made of timber. A typical design features a frame of beams and posts that make up the internal and external structure of the building and supports the entire home without the need for interior load-bearing walls.

But there are lots of variations in timber frame construction design thanks to the essential versatility of the basic material, which in turn enables enormous flexibility of design. Indeed, as there are usually no interior load-bearing walls, your floor plan can be as open as you like and can be adapted to suit your changing needs.

In the past there was a common misconception that a timber-framed house was essentially the same thing as a log house/cabin or a timber-clad house. You can of course clad a timber-framed house with anything you want: wood, fibre-cement or other building boards, brick, render, or stone. In Ireland it is popular to build the external leaf with rendered blockwork, though alternative options such as rendered cement fibreboard can provide the same aesthetic and performance. Moisture barriers are incorporated within the wall structure itself.

System types

At the most basic level, there are essentially two types of timber frame construction: stick-built (built on site) or prefabricated (built in a factory and erected on site). Prefabricated timber frame can be further divided into two types: open panel and closed panel.

Open panel systems are structurally engineered panels that form the inside load-bearing leaf of the external wall, typically comprising studs, rails, plywood or OSB sheathing on one side and a breather membrane on the other. They are manufactured in the factory ready for fitting to the frame on site, after which the external joinery (doors and windows) wiring, plumbing and insulation is then installed.

Closed panel systems are where the wall panels are made in their entirety in a factory, including the insulation – and in some cases even the wiring, plumbing, window and door linings and possibly even the external cladding, leaving very little on-site work.

The two big advantages of prefabricated systems in general, of course, are speed and quality. With most of the work done in a factory, it reduces the amount of time needed on site compared to stick-built or masonry homes. The factory environment that makes greater economies of scale possible also enables greater quality control, particularly in relation to insulation and fittings.

Cork-based Cygnum Timber Frame has developed a strong operation in producing closed panel systems for clients all over Ireland and the UK. Technical sales director Heber McMahon says: "We have a lot of automation in our factory, more so than most other companies to eradicate human errors." This is particularly the case when it comes to important details like designing in the appropriate fire protection to partition walls, cavity barriers and plasterboarding.

McMahon says that new building regulations have created a massive amount of paper work for builders, "whereas we take over a lot of that for them because we're manufacturing it [offsite]".

Perhaps the one big disadvantage of prefabricated frames is that it can be difficult to modify the structure once the frame is finished. Because of this, the design should be exactly right for the plot, and the work should only be done by a competent frame erection team to ensure it lines up perfectly with whatever foundations are in place

A relatively recent innovation in timber construction is SIPs (structural insulated panels), which are essentially insulated timber panels assembled together, often without the need for a timber frame. SIPS are usually made up of two sheets of OSB sandwiching a rigid core of polyurethane foam – though other insulants can be used – giving strong structural strength with high levels of insulation for use in walls, roofs and floors.

According to the Structural Timber Association in the UK, there are two fundamental applications for SIPs – a full load-bearing structural wrap or infill walling, where the panels are specified as infill to the timber frame. A similar system is Glavloc from Cork, which makes a high-performance timber and EPS-based build system designed to enable simple, rapid build to passive house or NZEB levels.

> Ensuring breathability is crucial.

Single or double stud

Timber frames can be designed with double stud or single stud structures. Double stud is typically used when the wall thickness needs to be more than the 200mm possible with single stud – a good example being the 300-400mm twin stud wall that MBC Timber Frame have used on many passive house projects published in back issues of this magazine. But arguably a more important advantage of double stud is that it cuts out cold bridging, particularly given that the ratio of timber to insulation in a single stud building can up to 25pc compared with 15pc in a double stud set-up.

"The twin wall, double stud system is designed to cut out that cold bridging, so you increase the thickness of the insulation around the studs. But you end up with spaced studs, so you get much better cold bridge-free structure," says Meade.

Breathability and thermal mass

Ensuring breathability is crucial in a timber frame construction. Most build-ups become more breathable, ie more vapour open, towards the outside of the construction. So, an airtightness and vapour control layer toward the inside and a more open breather membrane towards the outside of the build up, allows vapour and any moisture absorbed during the building phase to diffuse out of the construction.

According to Niall Crossan of Ecological Building Systems, the thermal insulation in between these two layers should also be breathable – otherwise the timbers will take longer to dry out if wet and the natural path of vapour diffusion will be significantly reduced. He recommends natural insulation like hemp, woodfibre or cellulose – all of which the company provide. "Aside from their lower environmental impact, they also present the technical advantage of hygroscopicity, which helps offset interstitial condensation risk within the structure."

When compared with bricks and mortar, there is a common perception that timber frame is a relatively 'lightweight' building method, but it can be made 'heavier' to offer greater thermal mass, such as by using a heavier density insulation material. "It can all add up and you're still not looking at anywhere near the density levels of concrete," says Jasper Meade. Adding density can help significantly to reduce the fluctuation of temperatures over the winter but also decrement delay in summer – where the building is capable of absorbing and delaying the release of daytime heat until the night, when temperatures may be significantly lower. Other solutions can involve laying concrete screeds on first floors or building a structure with exposed heavy beams.

Cladding

Timber-framed houses need a layer of external cladding to protect them from moisture, ideally with a ventilated cavity. As mentioned above, timber-framed houses can be clad with a wide range of external leaves including brick or block, but also cement fibreboard, stone, metal and timber. Indeed, there is a bit of a current fashion for timber cladding. Jasper Meade of Welsh closed panel timber frame manufacturer PYC is a fan, arguing that it can be incredibly practical in the long-term. "It's all about the detailing, if the rest of the detailing is correct then it has very good longevity," he says.

Carbon footprint

One of the biggest selling points of timber frame construction amid growing environmental awareness and the demand for sustainable methods of building is that it is low-carbon – as long as the forests from which the timber comes are well-managed and replanted.

Timber frame can help to reduce the embodied energy of construction, for a couple of reasons: timber products tend to be less energy intensive to manufacture than steel or concrete, and the material itself acts as a carbon sink.

Growing trees soak up CO_2, meaning that timber products can lock in place emissions for the lifetime of the building. It is estimated that during photosynthesis, 0.9 tonnes of CO_2 is stored in every cubic metre of wood. When the building is demolished, the timbers can often be very easily recycled when they go out of use – though this will depend on the specifics of the build spec.

An average timber frame house uses approximately 5-6 cubic metres more wood than a traditional masonry house (which also has roof and floors in wood), thereby saving up to 12 tonnes of CO_2. And according to Wood Knowledge Wales, if all houses in the UK built since 1945 had been timber frame, over 300 million tonnes of CO_2 would have been saved.

According to David Murray of MEDITE SMARTPLY, while tightening energy performance requirements under building regulations are ensuring that new builds are moving in the right direction in terms of energy used to operate buildings, there's been insufficient focus on embodied energy – and such is the urgency of the climate crisis, it may no longer be acceptable to justify considerable CO_2 emissions to construct new buildings even if those buildings are designed to emit little over their lifetime.

"Carbon reduction is only measured or incentivised in terms of energy efficiency, such as space and water heating through Part L," he says. "Today though, materials account for a higher percentage of carbon emissions, so this should be incentivised."

Durability

Though in markets like Ireland the concrete lobby has in the past sought to capitalize on people's lack of familiarity with timber frame by raising doubts about its durability, in fact the evidence paints a different picture: the oldest example in the UK is a stave church built in the 11th century, while even older examples include the age-defying Horyuji Temple in Japan, which is still pristine some 1,300 years after it was built.

A study carried out by the BRE on more than 100 timber frame houses that had been built up to the end of 1975, found their performance to be "similar to traditionally built dwellings of the same age and, given proper maintenance, they were found likely to remain in that way for the foreseeable future".

Acoustics

The science of sound transmittance is about much more than just the structure of a building, taking in anything from building form, to finishes and material densities. But with good design and quality construction, timber frame buildings can achieve superlative acoustic performance, as developer Michael Bennett's low-cost passive house scheme in Enniscorthy demonstrates.

As reported previously in Passive House Plus, acoustic tester Ted Dalton of Dalton Acoustics recorded levels of 63 and 69dB at the party walls he tested in the homes – a marked improvement on the regulatory target of 53dB or higher. "The higher result [of 69dB] is akin to the kind of sound insulation we attempt to design into walls between commercial cinemas," says Dalton. "I've never seen a result like this on a party wall."

Quality is critical to results like these: Bennett built the homes with one of Ireland's leading timber framers, Shoalwater Timber Frame, and the impressive result owed to a combination of factors including high levels of airtightness, and a carefully conceived build-up including high density cellulose, ProPassiv OSB, and two layers of Gyproc wall boards, one of which has strong



Metal web joists

One innovation that has proven popular in recent years is metal web floor joists, which offer advantages including the ability to run building services seamlessly through the joists. Care may be required on the overall floor/ceiling build-up to ensure that penetrations don't compromise fire safety.

acoustic properties – with joints staggered to reduce noise levels.

Fire prevention

There's a common conception that timber-framed homes are inherently at greater risk of fire because of wood's combustibility. However, timber frame construction and its components are highly regarded by many in the matter of fire safety and can meet all fire standards under current building regulations.

All buildings, irrespective of construction type, must meet very stringent regulations with respect to fire safety. The plasterboard in timber frame buildings will help to protect the underlying structure from high temperatures. "The real danger of fire in any building is time, and so making sure that there is time to escape and for time to extinguish the fire, so compartmentalizing and fire stopping between sections of buildings is crucial to get that right," says Meade. "But also ensuring that if you're using timber, you've got material which chars and smokes." Wood chars at a known rate. The argument goes that at high temperatures, the outer char layer protects the wood underneath and prevents structural collapse.

Height

Although timber frame tends to be restricted to in the order of three to four storeys in the UK and Ireland, recent innovations in timber engineering mean that mass timber methods are starting to be used to build to remarkable heights. In the last few years, timber structure buildings of up to 18 storeys have been completed while two timber buildings clocking in at over 80 metres tall are currently under construction – the 24-storey HoHo Wien in Vienna, and Mjøsa Tower – an 18-storey Norwegian Tower nearing completion that's on course to be the tallest timber building ever built.

Housing crisis

In Ireland, where there is a serious crisis in the supply of new homes, there is strong feeling among some in the industry that the benefits of timber frame are not well understood by policy makers, and therefore not incentivised.

Pre-fabrication can enable rapid-build without compromising build quality, but the very term prefabricated is a problem, because of its association with cold and cheap-feeling prefab units.

Where advocates may want timber frame to be recognised for the high-quality builds being produced and its sustainability, speed is still the biggest draw of timber frame, as it was during the last Irish property boom when over 30% of the homes built in Ireland each year were made of timber.

TIMBER STRUCTURAL ELEMENTS

When it comes to the methods of constructing the main structural elements of a building, there are lots of timber-based options, each with their own advantages.

BRETTSTAPEL

This rarely seen method which literally means "stacked planks" is a form of solid timber construction that does not use glues or nails. It's made by connecting softwood timber posts together with hardwood timber dowels. The advantage of this relatively simple method of construction is the capacity to use low-grade timber to form load-bearing solid timber wall, floor and roof panels. The dowels have a lower moisture content than the posts, so over time the dowels expand to achieve moisture equilibrium, thus 'locking' the posts together and creating a structural load-bearing system.



BRETTSTAPEL

Methods like CLT and Brettstapel can enable use of lower quality wood being adhered together to form strong structural elements. As an example, Brettstapel was used to form the curved walls of the Pod building at the Burry Port school in Wales, which houses the school's performance and recreational spaces. The Brettstapel system was manufactured in Ireland by Cygnum, using Welsh softwood — low grade timber that would otherwise end up in pallets, woodchip or fence posts, thereby boosting its sustainability credentials.

Low-grade timber often includes a lot of Irish/British produce of fairly poor quality because it's grown on poor quality soils. However, Jasper Meade of PYC insists that certainly in the case of brettstapel, there is a "phenomenal" amount of timber in the wall structure, so it needs to be of decent quality, while CLT is typically made out of a high-quality European timber and there's a high-quality process involved in manufacturing it.

CLT

Cross laminated timber (CLT) is a structural two-way spanning solid wood panel product that can be used to form walls, roof and floor panels as well as shear walls. It is produced by stacking a number of layers of timber, known as lamellas, at 90° to the layer below, and subsequently glued to create panels of up to 24m in length and 3m in width, which can encompass between three and seven layers.



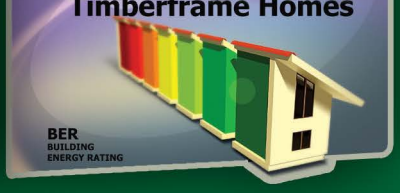
CLT

CLT may prove particularly advantageous in high-rise or commercial buildings, where the cost reductions from using lorries and cranes come into their own, though the material is becoming popular for smaller-scale buildings too. Firms like PYC have also used it on projects where the internal finishes need to be exposed and not plasterboarded. "With CLT you've always got to put thickness of insulation on the outside of it, so that might be done with wood fibre or studs with cellulose inside it," says Jasper Meade of PYC.

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David Murray, head of innovation at MEDITE SMARTPLY, says panelised timber frame is cost-effective and proven technically for medium rises of up to six storeys, meaning CLT tends to be used less in small projects. That said, as past issues of Passive House Plus have attested, CLT has been used on small scale passive house projects too – notable examples including buildings built using CLT from British manufacturer Eurban, Spanish manufacturer Egoin and innovative modular passive house builder, Kiss House.

LARSEN TRUSS

A type of wall truss used to build a wall thick enough to provide room for above-average amounts of insulation, unlike conventional wall trusses, a Larsen truss is not structural or load-bearing. It is typically made up of two long pieces of solid wood held a distance apart by a piece of plywood or OSB and attached to the outside of the sheathing.



LARSEN TRUSS

I-JOISTS

These strong, lightweight 'I' shaped engineered wood structural members are an increasingly popular choice. An I-joist comprises two main parts, the web and flange. The web is sandwiched between a top and bottom flange, creating the "I" shape. The flange can be made from laminated veneer lumber or solid wood finger-jointed together for ultimate strength. Besides offering a higher strength-to-weight ratio than conventional wood joists and thereby outstanding resistance to shearing, twisting or splitting, I-joists are ideal for projects that seek to use minimal timber and lots of insulation.



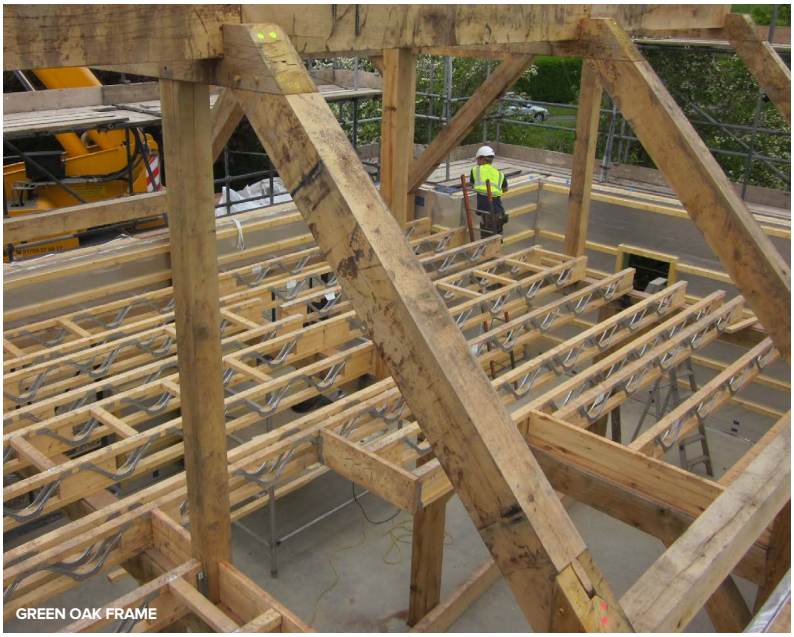
GLULAM

GLULAM

The popular name for glued laminated timber, glulam is a manufactured timber product made by bonding together individual laminates (layers) of solid timber boards with durable, moisture-resistant structural glues. The laminations are usually made of spruce or pine but also larch, douglas fir, or even hardwoods like oak. One of the greatest advantages of glulam is that it can be manufactured in a wide variety of shapes, sizes and configurations, and is commonly used for points in a timber frame that requires a stronger structural support.

GREEN OAK FRAME

Often referred to as exposed timber frame, this is the most traditional timber frame building method. The oak is often jointed using mortise and tenon joints, which are draw-pegged with tapered oak pegs. The structure is integrally braced with curved oak bends jointed into the frame. The massive oak skeleton is then infilled with insulating panels and made waterproof by a system of perimeter trims and water bars before being rendered on the outside, leaving the timbers exposed.



GREEN OAK FRAME



TANZANIAN CHILDREN'S ECO VILLAGE

AIMS TO INSPIRE LOW CARBON EXAMPLE

In 2016, three British sustainable building experts were asked to design a new school, housing and other facilities for an eco village in Tanzania that caters to the country's orphans. They aimed to take the principles of passive house design and apply them in a low-cost, low-tech manner to demonstrate that sustainable, comfortable and affordable buildings could be accessible to the people of rural Tanzania. This is the story of the project so far.

Words by Andy Simmonds, Simmonds Mills Architects

Simmonds Mills Architects were approached in 2016 by Kamran Fazil of iHelp, an international charity based in Birmingham, to support them with one of their initiatives — the Children's Eco Village in Tanzania.

Established in 2012, the Children's Eco Village aims to give orphaned children in Tanzania a better and brighter future while promoting practices that are sustainable and environmentally conscious.

Located in the Mkurunga district south of Dar es Salaam, the eco village aims to demonstrate to the local and wider community that it is possible to live and learn comfortably with a low carbon lifestyle.

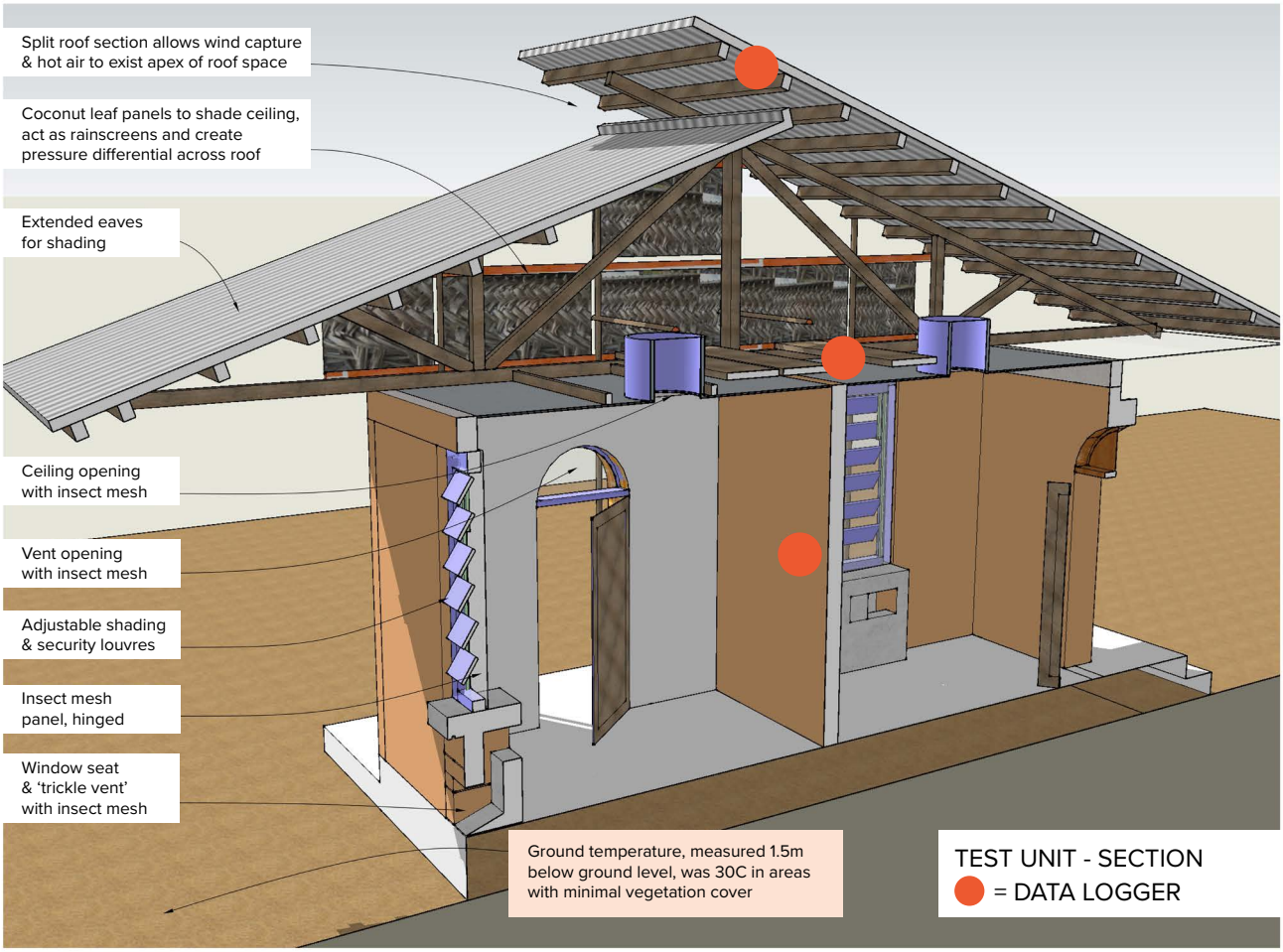
iHelp's brief to Simmonds Mills included master planning for the site, more and better-performing living accommodation for the children, new educational facilities, and on-site accommodation for a head teacher and the farm manager.

There was also a need to rectify some faults with the previous four houses that had been built, including roof leaks, fruit bat related damage, and associated health problems. In addition, there were overheating issues in some of the bedrooms.

The focus of Simmonds Mills is on delivering buildings to the passive house and AECB building standards, but we have also developed an eclectic mix of design and technical skills over the years, including hands-on experience with conservation work and innovative use of natural-fibre and earth-based materials.

Architect Adele Mills and I first visited the site in 2017 to meet the children and staff, including eco village manager Saidi Ngolola, and to get a better understanding of the local context, culture and climate.

Discussions then led to prioritising the designs for four new homes on site. Inspired by the work of West African architect Francis Kere, as illustrated in the book 'Radically Simple', the team progressed designs while applying their low energy and passive house design experience to maximise efficiency



Graphic showing the basic design principles of the test unit at the eco village.

and comfort — but responding to the 'cooling climate' of Tanzania rather than the 'heating climate' of the UK.

The PHPP climate data (derived from the Meteonorm dataset) for Dar es Salaam shows year-round temperatures to be in a comfortable range. It is fairly clear, however, that we don't expect to need heating in this climate: the minimum monthly average temperature is 24C, with night temperature of 19C. The question is what a suitable warm weather criterion is. Typical summer conditions are an average temperature of 28C (24C at night, max 32C in day) with relative humidity around 77%.

It was quickly apparent that a building physics-based approach was highly appropriate, but in contrast to a passive house in a heating climate like Britain or Ireland, the new homes needed to be draughty, and to be as shaded from the sun as possible.

We needed to find a way to create secure, private structures that replicate as closely as possible the conditions found in the shade under the cashew nut trees when a cooling wind was blowing – but without the night time mosquitoes.

Local architecture

The team looked at regional historical vernacular architecture and typical traditional responses to the climate, including how to keep the sun's heat (and heavy rain) out of the building through the use of natural fibre insulation.

Vernacular buildings on the nearby island of Zanzibar show historic and sophisticated responses to the need for shading, ventilation, security and privacy in their window architecture. The classic shaded window architecture seen on Zanzibar, a world heritage site, we think could become a critical part of our house and school designs.

Buildings in the historic centres of Zanzibar are built of coral stone (full of holes, so presumably good at keeping the heat out), and lime mortar and render. Use of quarried coral for building is obviously now prohibited, although one permaculture centre we visited on the mainland used coral stone found on site, and woven coconut panels for privacy screens and shading.

However, ultimately the team felt that it was important to 'meet people where they are' and to demonstrate how to build resource-efficient and comfortable buildings – without energy intensive air conditioning – using standard, widely used building materials.

Houses in the region are now typically built with locally made concrete blocks (made by local building suppliers with block presses using local sand and cement) and preservative

> The Children's Eco Village aims to give orphaned children in Tanzania a better and brighter future.









(clockwise from top left) A local architectural approach to shading and secure ventilation; woven banana leaves, like coconut leaves, are one material used for shading and privacy; group of concrete block and metal roofed homes on a local hillside; recycled coral stone was used in the construction of this Tanzanian permaculture centre.

treated timber. However, there are no timber sustainability accreditation schemes in the country that we are aware of, and we don't know what the preservative being used is. Houses are typically finished with plastic coated or plain galvanised profiled metal sheeting, often sporting a range of bright colours, with bright blue being particularly popular.

Passive principles in Tanzania

One of our aspirations was to explore how passive house design principles could be applied to the Tanzanian climate, and the country's economic and cultural context. For Tanzania, one could design a well shaded, insulated, sealed box with enthalpy recovery ventilation and cooling – and come in under the passive house standard 15kWh/m^2/yr cooling demand. However, this is an expensive solution and actually incurs higher energy costs than typical traditional building stock (i.e. none).

In addition, by this definition in rural Tanzania the majority of the population cannot afford a passive house, or passive house levels of comfort. Yet - as in the UK - people here need better buildings.

Our approach instead was to show a low-cost, low-tech design can create conditions where air conditioning is not needed. Soon after our first visit to the nearby city of Dar es Salaam and to the eco village, and as a result of discussion with eco village staff and the charity, we came to the clear conclusion that an insulated, airtight building with mechanical ventilation is not economically or practically viable in rural Tanzania, and so we adopted what the Passive House Institute termed the 'classic tropical approach' to building design.

Instead, we proposed taking a bioclimatic approach to architecture and delivering improved comfort with no energy use for heating or cooling. Our approach uses shading – both of the walls and window openings, and also of the roof of the building – via a double roof comprising a well-ventilated rainscreen that shades the ceiling of the internal spaces.

The aims of the passive house standard, according to the online reference Passipedia, include very low energy use for heating and cooling, passive cooling through shading, a high level of comfort including attention to radiant temperatures, and good ventilation. So how could we apply these principles in the Tanzanian context using our low-cost, low-tech approach?

- Ultra-low energy: we use zero energy for heating or cooling
- Passive cooling by shading
- High comfort & keeping internal air and surface temperatures similar to prevent condensation
- Ventilation: no need to recover heat so use controllable natural ventilation – draughts won't be unpleasant

We wondered if our design approach might be acceptable as a low-cost, low-tech tropical-climate interpretation of the passive house standard, and entered into correspondence with the Passive House Institute to see if they might accept such a definition, but while being supportive of our project, they argued that it could not be called a passive house (see 'Is thermal comfort adaptable?').

Based on an initial house design, we advised iHelp to first build a small test building to assess the viability, practicality and performance of the larger design. Various key features from our proposed house design were identified and incorporated into the test unit. The test unit would also provide the eco village with toilets, showers and two bedrooms for guests (I stayed in the finished building along with heating and ventilation engineer Alan Clarke, the third member of our design team, during a site visit last year).

The test building

The materials chosen for the test building were:

- concrete block walls with sand cement render and plaster, concrete in-situ rings beams along wall tops
- sawn timber roof structure
- stone-filled solid floor with concrete slab, incorporating a plastic damp proof membrane, tiled finishes
- plasterboard and gypsum skin ceiling
- plain galvanised metal roofing.

We looked into using either rammed earth or earth blocks, and while we did find suitable soil from a nearby building site, it was gone by the next day, so we recognised that in a basically sandy region, we could not rely on any sources of suitable soil without much more coordination, better suited to a bigger project.

However there remains a good chance that local building-quality soil could be found for larger projects and that the house or school wall designs – intended to be material agnostic — could, as opportunity allows, be substituted in part with earth construction.

Throughout the test unit build, the team communicated through WhatsApp, which proved to be invaluable, allowing issues to be communicated and resolved between the team on the ground in Tanzania and the design team in the UK.

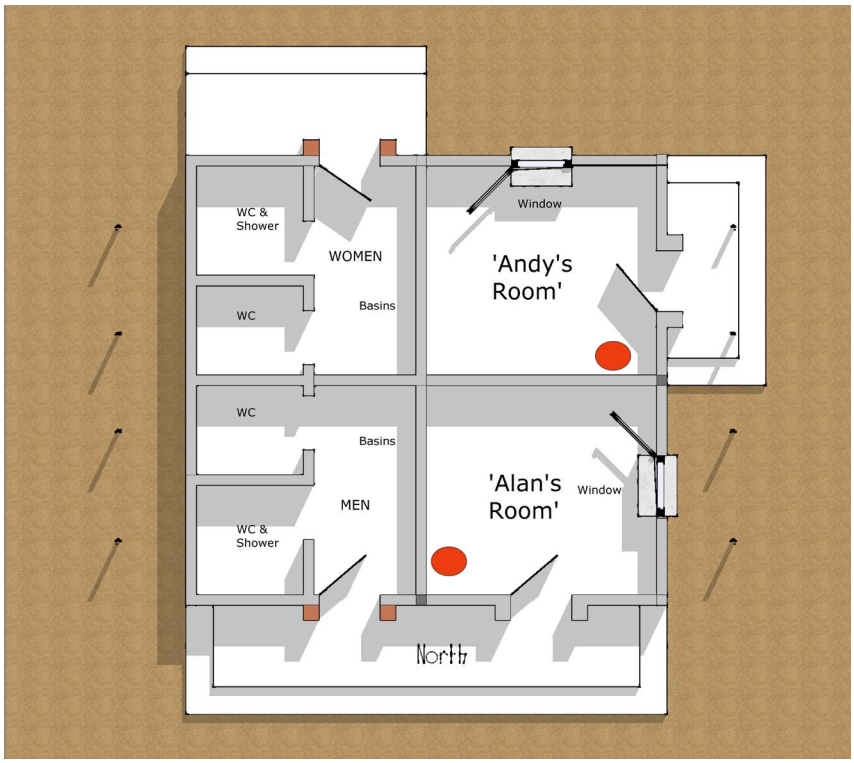
Work on the test building began in November 2017 and was completed in September 2018 (work was interrupted several times). Gemini Data Loggers Ltd kindly donated several TinyTag data loggers to allow the team to measure temperature and relative humidity on site. We installed these data loggers in a few different places:

- under a tree outside, in the shade but exposed to wind movement, to measure ambient environmental conditions
- at head height in a bedroom in an existing house ('House 4'), main elevations facing east/west
- at chest height in the test unit's two bedrooms (where Andy and Alan stayed during a 2018 visit)
- just below the metal roofing at the split section apex of the test unit
- just above the plasterboard ceiling of the test unit.

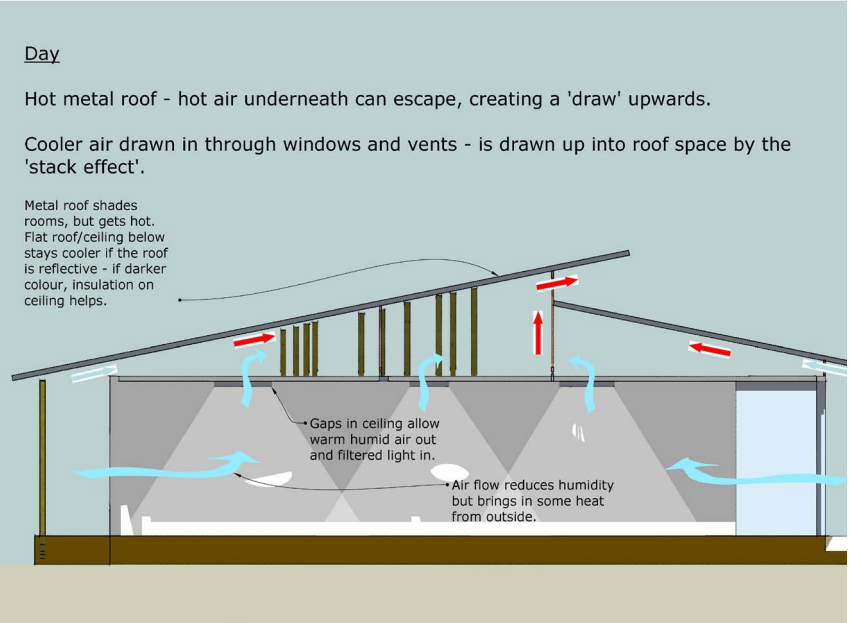
The main conclusions from three months of monitoring, from November 2018 to January 2019, are:

- daytime temperatures in House 4's bedroom are much higher than in the test unit bedrooms
- bedtime (evening) temperatures in House 4 and the test unit rooms are similar for a short period, but the rooms in the test unit cool down more quickly during the later evening and during the night
- after sunset there is a time lag — before the test unit rooms start to cool down — of about two hours for the better-shaded bedroom (Alan's), and three hours for the other (Andy's)
- it is obvious that the concrete blocks retain daytime heat and prevent more rapid cooling of the rooms in the test unit
- the roof space temperature above the plasterboard cools down closely (about 1C higher) following ambient external temperature, no doubt due to the low thermal mass of the plasterboard
- the temperature under the higher part of the roof, directly below the metal roof sheets, falls in line with external temperatures between sunset and sunrise, but presumably due to radiant heat loss (to the sky) actually falls about 0.5C lower than the measured external ambient temperature
- in addition, infrared photographs showed higher temperatures in the masonry walls where the contractors had picked out the corners of the rendered and painted masonry walls with a darker coloured paint – this effect was noticed in all areas where darker paint was used, e.g. window frames.



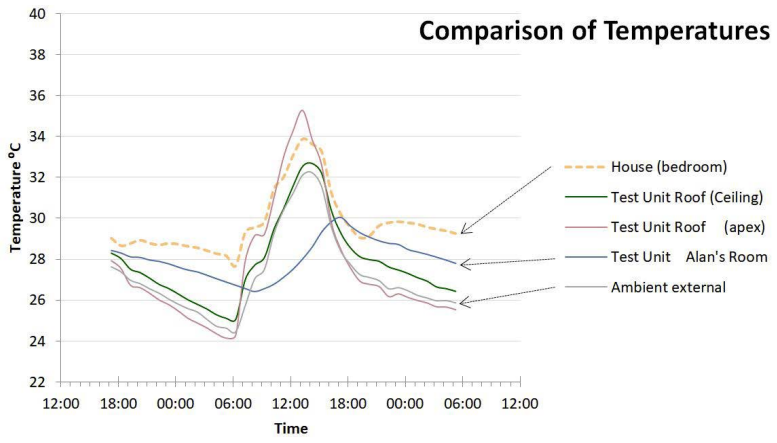


(top) Design team, left to right: heating & ventilation engineer Alan Clarke, and Adele Mills and Andy Simmonds of Simmonds Mills Architects; (above) floor plan of the test unit, showing the bedrooms Alan and Andy stayed in during their 2018 visit.





(above) The team investigating the roof space of the test unit which is used for passive stack ventilation aided by a gap (inset) in the ceiling; (top) image showing some of the design principles for keeping buildings at the eco village comfortable and well ventilated during the day.



Comparison of temperatures between the outdoors, an existing house on site at the eco village, and three different locations in the test unit, for 21 November 2018.

The main conclusions we have learned that will now be factored into our house designs:

- the roof design of the test unit successfully shaded the rooms' walls and windows and the surrounding area, keeping them significantly cooler than external temperatures between sunrise and sunset. Thus, the design would work well for rooms used during the day
- one issue was that the as-built orientation of the building's main elevations was around 20 degrees off a true north-south, resulting in late afternoon sun entering the window and heating the corner masonry of Andy's room
- another issue was that the contractors had installed glass louvres rather than timber louvres on the windows, resulting in more solar gain than planned. White paint was applied to the glass during the design team's stay, but this was considered only partially effective at reducing solar gain through the south west and west windows
- after sunset the thermal lag of the masonry walls and solid floor meant that useful evening cooling was delayed by a few hours resulting in uncomfortably high room temperatures at bedtime. This is where (insect protected) occupant cooling from air movement becomes important to maintain comfort. The design team realised that greater window opening areas were required, and ideally on opposite sides of the room to maintain adequate cross ventilation, especially with an orientation that was maximised for shading rather than typical window direction (from the east). The use of (solar/battery powered) ceiling fans is envisaged for the revised designs to aid occupant cooling on hot, windless nights
- it is clear that less thermal mass would be an advantage
- the conditions most suited to sleeping appear to be in the roof space (at attic floor level) between sunset and sunrise, presumably due to the presence of minimal thermal mass and good levels of air movement here.

> The majority of the population cannot afford a passive house.





(above left) Proposed design of four planned homes at the eco village; (right) one of the Tinytag sensors that the team is using to monitor temperature and humidity in various parts of the buildings.

We have not identified any specific issues needing to be tackled with respect to Tanzania's higher humidity levels. As these levels are fairly stable throughout the year, we expect occupants to be well adapted for the ambient humidity (especially through choice of clothing), and the well-ventilated approach typical of traditional building in hot humid areas will provide conditions perceived as comfortable.

Our design for the proposed school also now includes an open double roof structure with double eaves and a central air exhaust route at the ridge, large overhangs, natural ventilation through adjustable window louvres, and ceiling vents. The masonry structure won't include insulation given that external temperatures are so close to the desired internal temperature.

High levels of natural ventilation will tend to bring in warmer air during the afternoon, but this may be the price to pay for pleasant air velocity to help address the usual high relative humidity levels here. The PHPP model of our initial school design shows that internal temperatures are well controlled. Though with the high level of natural ventilation there is a large daily temperature swing, the PHPP overheating frequency is low using a 28C design condition.

It has been a salutary experience for the design team to simultaneously work in the UK — a temperate country with a growing focus on demand reduction, where we have the highest historical per capita emissions — and in Tanzania, a tropical country in the early stages of being industrialised, with citizens currently having only a fraction of our carbon emissions, and for whom it is hard to deny a fair, growing share of resources and energy use. Even in the context of the Tanzanian climate becoming more extreme, we still hope that the eco village's optimised, resource-efficient experiments in building might prove to be a more sustainable way forward for rural Tanzania.

IS THERMAL COMFORT ADAPTABLE?

The controversial concept of adaptive comfort posits that the range of comfortable living temperature for humans isn't necessarily biologically fixed and that we can adapt somewhat, at least within a certain range of temperatures.

The Tanzanian climate is hot but not extreme. Adaptive Thermal Comfort (Nichol Humphreys & Roaf 2012) sets out research which demonstrates how people adapt their clothing, behaviour and even metabolism to maintain comfort in temperatures up to the low 30s. With year round warm-to-hot temperatures, the expected comfort temperature at our site will be higher than in a cool temperature climate.

There are various standards for adaptive comfort. Ashrae 55 presents a method for calculating an adaptive comfort temperature standard based on the rolling mean external temperature. For our typical summer condition this works out as 26.5C, with upper limits of 29 or 30C and lower limits of 23 or 24C. The European standard EN15251 has similar criteria, and give us an ideal comfort temperature for our site of 28C, with a range of 25 – 31 C.

We put our idea of a low-cost, low-tech tropical-climate interpretation of the passive house standard to the Passive House Institute, but they were sceptical of our use of the adaptive comfort model, with the institute's Juergen Schneiders stating:

"Adaptive comfort has been widely discussed for decades, but nevertheless everybody who can afford it installs air-conditioning systems in hot countries. The main reason seems to be that the derivation of the adaptive comfort standards is methodically questionable for situations where it predicts higher comfort temperatures than approximately 26C: a comfort temperature is derived from a limited number of measurements at uncomfortably high indoor temperatures. There is an unexplained contradiction to other results: Fanger's experiments have shown that there is no physiological adaptation [to higher temperatures], it could only be psychological (you get used to it) or behavioural (you dress lightly and move slowly). Also, the evaluations of deDear show that in only three of 116 field studies the preferred temperature was above 27C. The baseline is: if you adapt to sweating, it is not as stressful as it would be for an unaccustomed European. But that's not thermal comfort."

Marketplace News

Green Building Store publishes radical retrofit briefing





Green Building Store has published a free technical briefing on its award-winning radical retrofit of a traditional Pennine farmhouse & barn in West Yorkshire, which developed innovative solutions for hard-to-treat buildings with solid walls.

The Lower Royd retrofit was modelled using the Passive House Planning Package (PHPP) to develop a whole-house strategy, and the project utilised the passive house methodology to achieve optimal energy efficiency and comfort. It involved the innovative use of a cork-based internal wall insulation (IWI) that was vapour open and 'breathable' but also had good thermal performance (with a lambda value of 0.045 W/mK), and helped to deliver a wall U-value of around 0.36.

The Diathonite internal wall insulation (IWI) is composed of cork, clay, lime and diatomaceous earth. It was ideal for uneven walls of the traditional stone-built farmhouse and barn, and was spray-applied to a thickness of 100mm, a depth previously not trialled for Diathonite IWI.

The project won the 'Vision & Sustainability' award at Leeds Beckett University's RISE 2017 Awards. It represents a development in Green Building Store's understanding of the 'whole house' radical retrofit and approaches to minimising moisture risk when using IWI. The project is helping to inform other radical retrofits with ongoing academic research now being undertaken.

The capillary and vapour open nature of the IWI insulation was important to help manage moisture risk at the project. The combination of cold solid walls, high exposure, driving Pennine rain and the potential for interstitial condensation meant that any IWI system used had to be extremely robust in its ability to deal with moisture and inhibit the risk of mould growth. Diathonite can absorb large amounts of water and let it out again without damage. It is also alkaline, meaning that mould growth is inhibited.

The technical briefing, aimed at self-builders and building professionals, details the measures undertaken as well as examining both the pros and cons of these approaches, and the challenges encountered by the project.

Bill Butcher, director of Green Building Store, commented: "There were issues with the drying out time at the project, and with detailing for airtightness. There will be pros and cons of any solution, but we need a range of solutions for this challenging level of retrofit. Our work on this project has demonstrated that Diathonite can offer a potentially viable solution, and we would certainly consider using it again at this thickness in a similar situation."

The briefing can be downloaded at **www.greenbuildingstore.co.uk/lower-royd/**. ■

(above left) Green Building Store retrofitted this traditional Pennine farmhouse and barn with a breathable internal wall insulation system.

New London school campus built with Nudura ICF

When Nudura's insulated concrete form (ICF) technology was specified for the £24.9m Inclusive Learning Campus project at Woodside High School site in London's Wood Green, airtightness testing of Block W blitzed the project target by hitting 2.18 m^3/hr @50 Pa. The project had set out to achieve a rating of 5.0 m^3/hr through well-designed detailing and quality assurance.

The Nudura ICF system was chosen for its ability to accelerate the build process, contribute to energy efficiency and design flexibility, replicate architectural features of existing buildings and its ability to be constructed in a live school environment with minimal disruption.

Nudura forms enabled each building envelope to be made watertight earlier in the construction programme than traditional methods, and permitted fitting out to commence some ten weeks sooner than with conventional blockwork. Moreover, even the freezing winter conditions did not delay the build, since concrete can be poured in temperatures of minus 30C.

The Inclusive Learning Campus was constructed with sustainability firmly in mind and Nudura contributed significantly towards achieving greater overall energy efficiency through good thermal insulation and air permeability. A decade ago, Nudura ICF technology had already been used to build the first certified net zero energy school in North America — the LEED Gold certified Richardsville Elementary in Bowling Green, Kentucky.

Terry Smith, director of the Woodside project's structural engineers, the Clark Smith Partnership, said: "The Nudura system has been well thought through and the product fits together very well using the special corner pieces. The propping system, with integral working platform, leads to simplicity and efficiency."

Jean-Marc Bouvier, Nudura's international sales & technical representative, added: "The builder friendly aspects of the Nudura system made for an easy transition for main contractors, Apollo as this was their first experience with this type of building system."

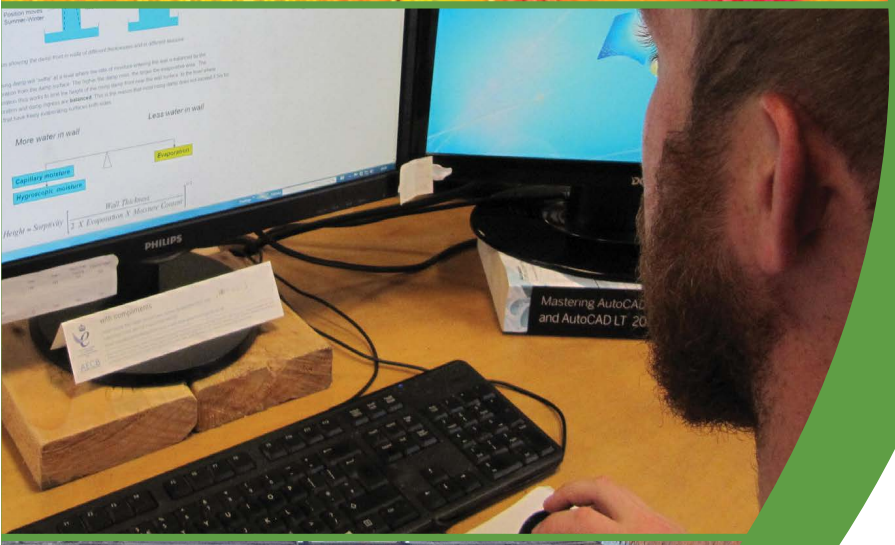
All forms are produced from recycled or recyclable material, using no ozone depleting processes, producing little waste during construction and emitting no CFCs or HCFCs. See **www.nudura.co.uk** for more. ■

(below) Pouring concrete into the Nudura ICF system on site at the Inclusive Learning Campus at Woodside High School.





"I wish this course had been available at the start of my career"
Daren, Architectural Technologist





"The knowledge gained from this course and how it will assist me in my work is well worth the time and very reasonable cost at the outset"
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Radial ducting key to good MVHR performance — Solarcrest

Ventilation specialist Solarcrest has advised anyone specifying a mechanical ventilation with heat recovery (MVHR) system to be aware of the key differences between radial and branch ducting.

According to Solarcrest managing director Eliot Warrington, branch ducting is frequently specified on projects because it's cheaper, but he said that apart from price, it offers few advantages over radial ducting systems. He said that Solarcrest only supply and install BRE-tested (SAP Q eligible) semi-rigid radial ducting with their MVHR systems.

Warrington added that some of the advantages of radial ducting include that it takes up less space, can be deep-cleaned in years to come (because there are no sharp bends), is quicker and easier to install, reduces or eliminates the need for 'boxing in', and that it is quieter and prevents cross-talk between rooms. He also explained that a good radial ducting system has around half the static pressure of a comparable branch system, meaning less fan power is required.

With radial ducting systems, a duct runs from an acoustic manifold that connects the MVHR unit to each room in the house, whereas with a branch system, a large diameter duct leaves the MVHR unit and runs around the property, branching off into each room, meaning sound can travel from room to room through the pipe. Radial systems typically have a greater amount of ducting in total, but that ducting is much smaller in diameter.

Warrington offered an analogy to explain the difference in acoustic performance: "Imagine you're driving down an old concrete motorway. There's a lot of road noise. You notice it when you hit a section of new tarmac, or rather when you come off the smooth tarmac and back on to the rumbling concrete. In terms of acoustics, branch ducting is the concrete road and radial is the tarmac."

He continued: "Acoustic complaints are not uncommon with MVHR, but 99% of them are due to the ducting and not the motor unit. They can be prevented if you fit enough of the right ducting. The only reason you'd choose a branch system is because it's cheaper and appears to do the same job. Problem is, people don't add the cost of the extra install time, the unnecessary boxing-in or the enormous silencers you need to mitigate acoustic problems when they're comparing quotes. By the time they realise the drawbacks, their system is already installed, and it can never be taken out. Cheap ducting and poor installs are giving the MVHR industry a bad name." ■

(above) Airflow Airflex semi-rigid radial ducting from Solarcrest.

Viessmann calls for best practice gas boiler rules

Leading boiler manufacturer Viessmann has called for an update of boiler installation rules in the UK in order to ensure best practice, maximise efficiency and reduce gas consumption.

Responding to the Committee on Climate Change's latest report, 'Housing: Fit for the future', and to its calls for greater uptake of low carbon heating technologies, Viessmann marketing director Darren McMahon said that, "mass deployment of heat pumps or hydrogen feels like an overstep if we can't get the simple things right like ensuring gas boiler installation best practice across the market."

He continued: "This is important not only because it delivers heating bill reductions for consumers and cost-effective decarbonisation, it is also necessary to prepare the stock for the widespread roll-out of low carbon heat technology that needs to operate at lower temperatures."

McMahon said that the 'boiler plus' policy introduced in April 2018 was a big step towards making advanced controls mandatory with boiler installations in the UK. However, he said that the policy did not go far enough.

"Boiler plus additional efficiency measures like weather compensation are not mandatory beyond the combi boiler market. That means that the 354,000 heat only/system boilers installed every year in England are not covered by the policy."

He added: "Boiler plus does not cover new build heating system installations. Therefore, the heating systems that are fitted in the 200-250,000 per annum new build market may be inferior in terms of efficiency than those being retrofitted."

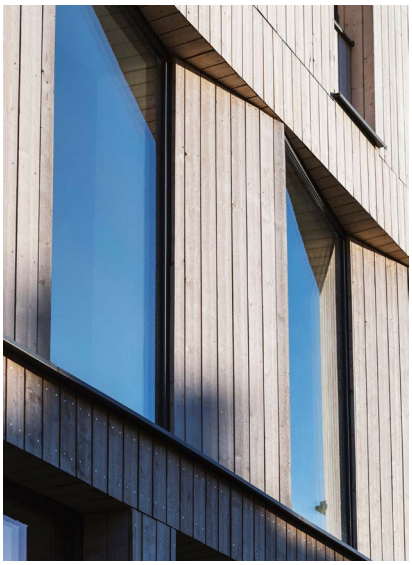
"Lastly, installation best practice is not addressed properly under boiler plus. Although the boiler plus consultation response notes that hydraulic balancing is 'expected practice' with boiler installations, it notes that it is not enforced, unlike in other major EU markets. This has the unintended consequence of confirming to installers that balancing is not mandatory, thus reducing this essential practice."

"This year will see the one-year review of boiler plus as well as a consultation on building regulations Part L. It is crucial that these gaps are addressed so that everyone can benefit from best practice." McMahon said that if boiler plus measures are extended beyond combis there could be up to 0.335 TWh of gas demand reduction in the UK in 2020, rising to 5.03 TWh per year in 2034. ■



(left) Viessmann marketing director Darren McMahon.

Always look for FSC-certified timber — Ecochoice



The array of timber cladding & decking choices on the market can seem confusing, particularly if you are looking to ensure the sustainability of what you specify, but engaging with an independent, expert supplier can help to demystify the wide range of products available. That's what Ecocoice, the leading supplier of FSC-certified timber cladding and decking products, has set out to do since 2005, the company's director Mike Bekin told Passive House Plus.

Ecochoice has supplied timber cladding for a number of high profile projects recently, including the Organowood fossilised timber cladding used on the Zetland Road passive retrofits featured in the previous issue of this magazine, as well as decking for the RIBA Sterling Prize winning Hastings Pier, and a new footbridge at Queen Elizabeth Olympic Park, London.

"One of the strengths we have is that because we don't have any stock based on the ground, we are totally free to offer expert advice based on what our clients actually want," said Mike Bekin. "We use our expertise in timber to find exactly what the client needs, as opposed to having something in a warehouse that we need to try to sell. We try to listen to what people want."

"People often don't realise there are so many options in timber cladding and decking. They tend to just say, 'give us cedar cladding and oak flooring', for example. But if you tell us what to you want to achieve, we can provide a huge range of options – usually cheaper and/or more sustainable than the original idea."

Bekin said that the company's particular expertise is in finding sustainably sourced timber products with a low ecological footprint (carbon and chemical). The company specialises in supplying products certified by the Forest Stewardship Council (FSC), which Bekin strongly believes is the best timber sustainability certification around. "People sometimes think specifying FSC certified products restricts your options, but actually there are lots of options that are FSC certified now," he said.

He added that the more people specify FSC certified timber, the more it will help to improve the sustainability of forests. "If you insist on buying certified tropical timber, you are actually helping to protect those forests from being converted into cattle pastures. We need to engage with it rather than avoid it," he said. "Nothing is better than tropical timber for durability. But if you're buying something tropical, please don't cut corners — make sure it is FSC-certified." ■

(left) Ecochoice supplied the Organowood sustainable timber cladding that adorned the rear façade of the highly ecological Zetland Road development from issue 28 of Passive House Plus.

Passive Purple offer guaranteed passive house airtightness

Airtightness membrane specialists Passive Purple are putting their money where their mouth is – by guaranteeing passive house levels of airtightness.

According to company managing director Alex White, the company's decision to back its airtightness claims for the Passive Purple liquid vapour control membrane with guaranteed performance was a no-brainer: "If it's installed by one of our installers or by Passive Purple we'll guarantee 0.6 air changes per hour."

White explains that the BBA certified product – which is VOC free and water based – also has remarkable radon resistance qualities and is certified as a radon barrier when used in ground floor build-ups and at ground floor to wall junctions. Radon, an invisible, odourless radioactive gas is the 2nd largest cause of lung cancer in the UK. Radon exposure in the home is associated with circa 1,100 deaths per year in the UK according to the NHS.

According to White, Passive Purple is class-C fire rated where most paper membranes have class-E.

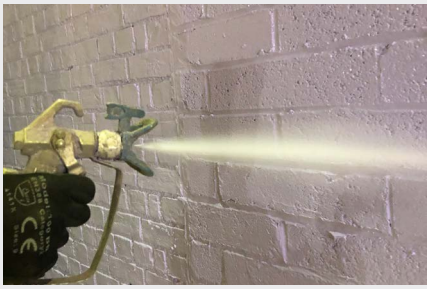
White said Passive Purple's robustness and flexibility is leading to it being used by a number of different offsite build system manufacturers including timber frame and SIPS manufacturers, in addition to the wide range of onsite applications, which can bring any build method up to passive house airtightness levels – from traditional masonry through to modern methods of construction.

"Passive Purple can be used in certain difficult locations as well as full envelopment covering," said White. "It all depends on the score you're trying to achieve."

Also available as a brush or roller-applied product, Passive Purple arguably comes into its own when sprayed. "Using an airless spray machine, we can come and install 300 plus sqm of membrane a day with a single operative," said White. "We also know that purple isn't every one's cup of tea and as our product can be left on show in places such as car parks and commercial stair wells, we have got Airtight White, with all the same great features as the Passive Purple."

Passive Purple is part of family run business Whites Carpentry Group which includes White Haus Bespoke Timber Frame, White Air, White Haus Bespoke Windows, Passive Schools and Intelligent Membranes Ltd. ■

(below) A wall before and after Passive Purple is applied.







Mapping the efficiency of Europe's buildings

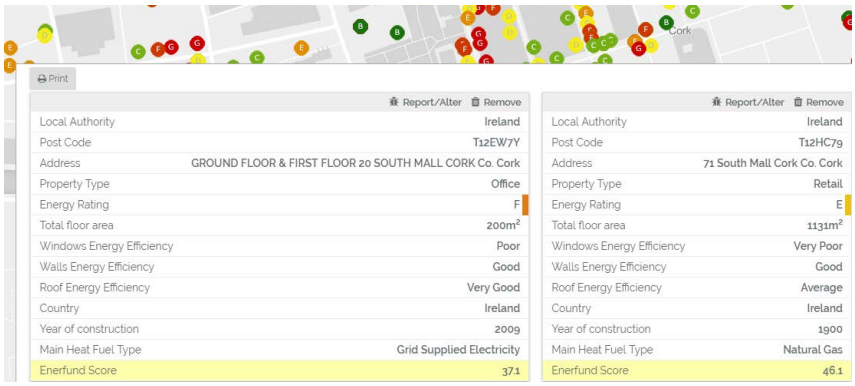
A new free-to-use online tool aims to map the energy performance of Europe's buildings, with the goal of helping to stimulate large-scale deep retrofit, writes project manager Michael Hanratty.

Investment in energy retrofit will form a critical part of the drive to cut Europe's greenhouse gas emissions. Buildings are responsible for about 40% of Europe's energy consumption, and about three-quarters of these buildings are regarded as energy inefficient. Stimulating large-scale deep retrofit will be crucial to transforming the continent's building stock.

The Enerfund programme aims to scale up investments in deep renovation of buildings. Funded by the European Commission's Horizon 2020 programme, it provides key stakeholders — such as financing institutions, energy service companies and local authorities — with up-to-date information regarding the energy efficiency of the EU's buildings.

The project has created a freely accessible application (http://app.enerfund.eu/) that maps the energy performance of commercial and public buildings in 13 EU member states, including Ireland and the UK, to building level. It also provides information for Bulgaria, Cyprus, Denmark, France, Greece, Italy, Netherlands, Romania, Slovakia, Slovenia and Spain. The data is based on the buildings' energy performance certificates (EPCs) or building energy ratings (BERs) in Ireland.

In several countries, residential EPC data is also available at building level — notably in England and Wales, Denmark and Holland. In addition to showing the mapped energy performance data, Enerfund has several innovative features. It includes filtering options to select buildings based on set criteria, and also provides the Enerfund score, which rates a building's retrofit potential.



(above) A comparison of the energy performance of two non-residential buildings in Cork.

Enerfund offers the opportunity to compare deep renovation opportunities of single buildings using data from EPCs/BERs and is constantly upgraded with more data and functionality. In total, data from more than eight million energy performance certificates (EPCs) are now embedded and geocoded into the tool, and more data is being added.

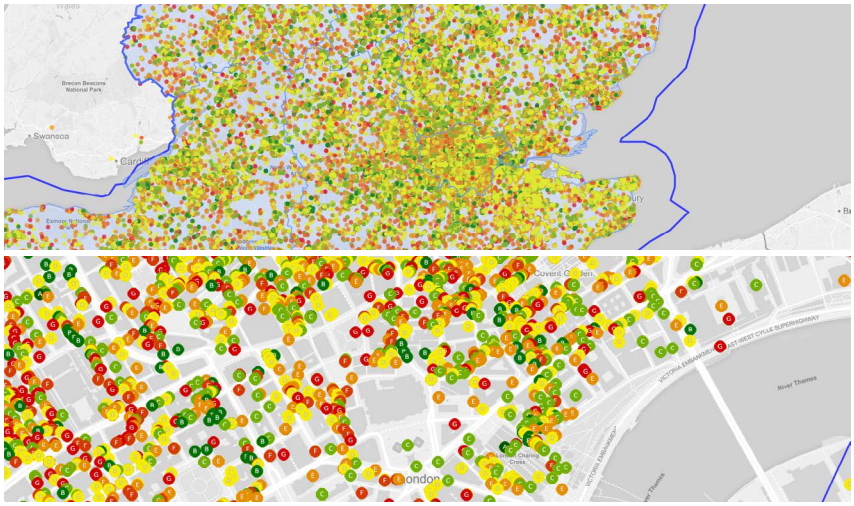
In Ireland, more than 60,000 commercial properties can now be viewed and interrogated for the first time via the tool. The filtering options include BER/EPC band ranges, floor area, building types, and fuel type.

Users can also pan in and, by clicking on rating circles, gather information on selected buildings. The example for Cork City pictured shows the results for two buildings selected for comparison. As well as indicating key attributes including BER, floor area, fuel types, age of construction and property type, it also provides the Enerfund score.

The Enerfund score is an algorithm developed to rate the retrofit investment potential of a building. It is a uniform scoring method for all datasets contained in Enerfund. The algorithm includes factors such as current rating, potential rating, floor area, age of construction, property price levels, noise levels, ownership, occupancy level and the owner's funding capabilities. Where no data for any of these factors is available, then default values are used.

During the project it was notable that the quality and consistency of EPC datasets, and access to those datasets, varied considerably across EU member states. It was also apparent that provision should be made to geo-code all national EPC datasets, and EU-wide consensus should be reached to address GDPR issues relating to residential EPC data in particular.

The revised EU energy performance of buildings (EPBD) directive entered into force on 9 July 2018. EU countries will have to transpose the new elements of the directive into national law within 20 months. The new directive has huge potential for efficiency gains in the EU building sector, the largest single energy consumer in Europe. It includes measures that will accelerate the rate of building energy retrofit and strengthen the energy performance of new buildings. Alongside the EPBD, Enerfund can be a useful and influential tool in strengthening the energy retrofit market in the years ahead. ■



(above) A map of EPCs for English dwellings, going down to individual building level.

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